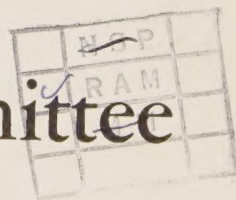


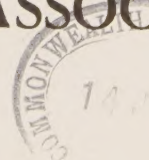


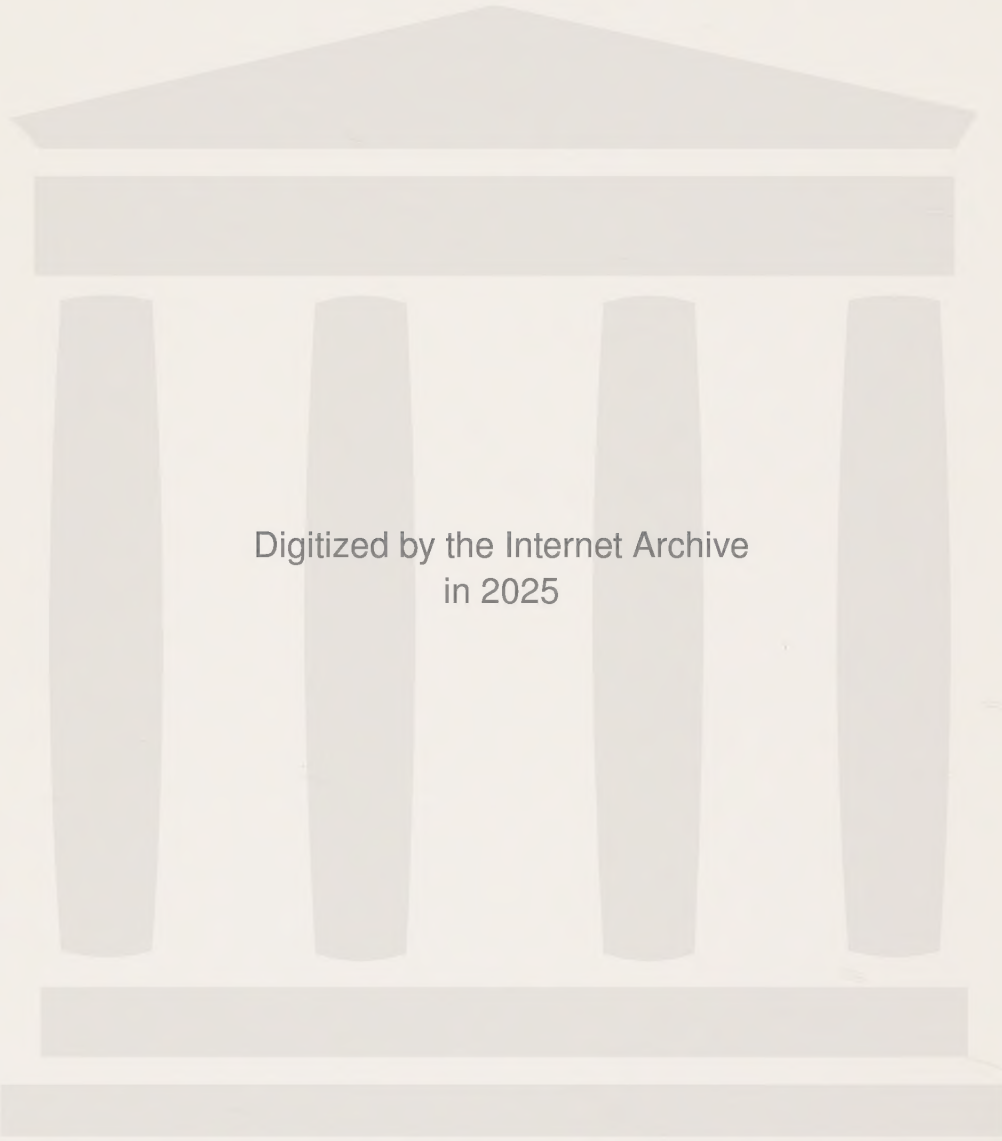
1957 Report

Experiment Station Committee



HAWAIIAN SUGAR PLANTERS' ASSOCIATION





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THE COMMITTEE IN CHARGE

THE EXPERIMENT STATION HAWAIIAN SUGAR PLANTERS' ASSOCIATION

REPORT

October 1, 1956 to September 30, 1957

CONTENTS

LETTER FROM THE EXPERIMENT STATION COMMITTEE.....	1
LETTER FROM THE STATION DIRECTOR.....	3
CULTURAL PRACTICES	6
DISEASES	21
FACTORY	26
GEOPHYSICS	31
INSECTS	35
IRRIGATION	41
MECHANIZATION	44
ORGANIC CHEMISTRY	49
VARIETIES	54
WEED CONTROL.....	65
TRAINING OF PERSONNEL.....	76
EXPERIMENT STATION STAFF.....	78
STATION PERSONNEL CHANGES.....	80

On the Cover:

Cooperative installation at HC&S to study the
consumptive use of water in relation to climate.
(Courtesy HC&S Co. Breeze)

To the President and Members

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

Gentlemen:

Presented herewith is the report of your Experiment Station for 1957. As with the 1956 report, I am sure you will find this complete, most informative, and of real value as a source of reference. I commend it to you.

The importance of thoroughly understanding a research program, its objectives, its progress and its significance to those it serves, cannot be over-emphasized. During the year, an objective analysis of the Experiment Station research program was made. This showed that research emphasis had been correctly placed, and also pointed out existing weaknesses. There is currently being developed a presentation of the objectives of our research which will give a clearer understanding of the results we hope to attain.

During the year, meetings of the Experiment Station Committee were held on each Island. At these meetings, the Station's approach to research was discussed in all of its aspects. Furthermore, the Island Associate Members, who attended each of our regularly scheduled monthly meetings, made invaluable contributions to the program of the year. Your Director is to be commended for the complete analysis he has made.

The Experiment Station is ably directed and well staffed. Research is intense and alert to technical developments. Our appreciation is extended to the Technical Advisory Committees, to the Island Associate Members of the Experiment Station Committee, and to the plantations themselves for their continued assistance and understanding during the year.

Respectfully submitted,

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Chairman

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To the Experiment Station Committee

Gentlemen:

This annual report of the Experiment Station for the year ending September 30, 1957, discloses the varied activities and research contributions to the sugar industry of a very competent staff of scientists. You will note that many significant steps have been taken to investigate more thoroughly many of the profound problems affecting the industry.

The year 1957 brought to the foreground rather vividly the tremendous deleterious impact that pests can have upon sugar production. Red rot disease in the variety 38-2915 caused considerable losses in sugar on the islands of Kauai, Oahu and Hawaii. Although the red rot organism has been known to be present in Hawaii, it did not show up on 38-2915 until 1954. Apparently weather conditions during the past two years had been conducive to a wide spreading of the disease.

Rat control problems were accentuated by damage observed on windward Kauai. A concentrated attack on the problem was launched with apparent beneficial results. It is significant to learn that the potential for similar damaging effects exists on the island of Hawaii.

A concentrated attack upon the nematode problem has been inaugurated by the Department of Pathology. The Department of Field Engineering has designed a soil fumigator for experimental purposes in this cooperative enterprise. Dr. Harold J. Jensen, Associate Nematologist at Oregon State College, joined the staff on August 5, 1957, on his six months' sabbatical leave, to spearhead the initial research in this expanded program.

The Department of Sugar Technology has begun its first experiments on the milling of sugar cane. This department has also made significant contributions to the cooperative project on sugar quality between the Experiment Station, the California and Hawaiian Sugar Refining Company and the plantations.

The problem of juice quality, which has been with the industry since its beginning, has become more acute in the last few years, apparently as a result of a combination of circumstances. In order to obtain basic information on the impact on juice quality of fertilizer amounts and distribution, as well as of climate, a group test sponsored by the Departments of Agronomy and Physiology and Biochemistry has been installed on the four Oahu plantations. A rather complete picture of the growth and quality of the cane is being obtained through a series of chemical analyses. We hope that this experiment will help to clarify some of the confusing concepts on juice quality.

A major coordinated effort is being made in the field of irrigation research. The irrigation research program of the Station had been handicapped because of the lack of personnel in the Department of Field Engineering and the absence of a coordinated program for the Station as a whole. The expanded program has been inaugurated by a visit to the Islands in July and August of Dr. Vaughn E. Hansen, Professor of Civil and Irrigation Engineering at Utah State Agricultural College, who was employed as Consultant to advise the Director and his staff concerning the entire irrigation problem of the industry, with particular emphasis on the engineering phases of the problem. Dr. Hansen has written a comprehensive report on his observations which has been distributed to the interested

parties within the industry. His report gives added emphasis to the Director's original concept of a coordinated approach across several departments in the solution of the many-fold problems that exist. In order to obtain the closest coordination of activities between the various departments and the plantations, the working committee on irrigation research has been set up with the Director as the coordinator, and representatives of the Departments of Field Engineering, Agronomy, Geophysics, and Physiology and Biochemistry as the members. The amount of work to be done is so large that the project will need the support of additional personnel.

In conjunction with the irrigation research program, one of the most extensive installations of lysimeter and meteorological equipment in the world has been set up on Maui in cooperation with the Hawaiian Commercial & Sugar Company in order to determine the consumptive use of water by the cane plant and its relationship to climatic factors.

The tillage and soil compaction research of the Station has been greatly strengthened by the addition to the staff of the Field Engineering Department of Walter W. Sewell as Project Engineer. His work will be closely coordinated with that of A. C. Trowse, Associate Agronomist, who spent six months at the National Tillage Machinery Laboratory at Alabama Polytechnic Institute, Auburn, Alabama. This is a world-famous laboratory, cooperative between the United States Department of Agriculture and the Alabama Agricultural Experiment Station. Hawaiian soils were used in the experiments conducted at the laboratory during Trowse's stay.

W. H. Kahl joined the staff of the Field Engineering Department as Project Engineer and will devote his major efforts to the field of handling and distribution of materials used in various cultural practices, such as fertilizers, herbicides, fumigant materials, and organic residues.

The auditorium in Agee Hall has been air conditioned and will be in use during the many meetings in the fall of 1957.

The members of the Experiment Station staff, and of the entire sugar industry, as well as many scientists throughout the world, were saddened by the death of Dr. Harold Lloyd Lyon, Director Emeritus, on May 15. He had been a member of the Station staff since 1907, and had made many outstanding and significant contributions not only to the Hawaiian sugar industry, but to the science of sugar cane itself.

Dr. J. N. Warner, Senior Geneticist, accompanied by Carl O. Grassl of the United States Department of Agriculture, spent five months in the New Guinea area searching for new germ plasm in both wild and noble canes. This was a cooperative endeavor by the United States Department of Agriculture and the Hawaiian Sugar Planters' Association. A sizeable quantity of new germ plasm was procured and will be added to our bank of breeding material.

Dr. G. O. Burr, Head of the Department of Physiology and Biochemistry, left on September 11 to attend the Second World Conference on Peacetime Uses of Atomic Energy, held in Paris from September 7 to 18.

Your Director and Dr. J. H. Payne, Head of the Department of Sugar Technology, attended the spring meetings of the American Chemical Society in Miami, Florida, and then went to the British Isles and Europe to visit scientific institutions and equipment manufacturers in order to obtain new ideas and information pertinent to the research program of the Station. Dr. Payne returned to Hawaii by the way of Australia, where he held extensive discussions concerning research in the milling phases of sugar technology. In Europe, we jointly looked into problems of continuous diffusion, continuous centrifugals, sugar quality clarification and instrumentation.

In addition to the work in sugar technology, your Director held many profitable discussions with European scientists in the field of plant analysis, plant nutrition, minor elements, water consumption by plants, and the production of dissolving pulp from bagasse. The highlights of the Director's scientific discussions have been sent to interested members of the industry.

During the year, 1,423 accessioned titles have been added to the Library. An inventory of the volumes in the Library showed approximately 52,000 catalogued volumes, 17,500 ephemeral items, such as State and United States documents, 2,000 serial titles and five newspapers. There were 2166 books circulated during the year, 279 of which were borrowed by other than staff members.

All staff changes are listed on page 80.

Respectfully submitted,

EXPERIMENT STATION, HSPA

L. D. Baver



Director

CULTURAL PRACTICES

FERTILIZER CONSUMPTION LEVELS OFF

Fertilizer consumption reached new highs in 1956 for both nitrogen and potash. Last year, the sugar industry purchased 20,980 tons nitrogen, 9365 tons P_2O_5 , and 19,808 tons K_2O . This year, fertilizer practices in general have leveled off, and some plantations have reduced the quantities scheduled for the 1958 and 1959 crops.

Increased yields in the past several years have em-

phasized that the newer varieties, given optimum growing conditions, can utilize the extra plant food and produce more cane and sugar. Under environments less than optimum, yield increases did not result from the last increment of fertilizer applied. Ceilings of sunlight and temperature during the growing of the 1957 crop must have played an important role in reducing the yields of cane and sugar.

AQUA AMMONIA TONNAGE INCREASES

More and more nitrogen is being purchased as aqua ammonia as most of the unirrigated plantations are obtaining equipment to apply this fertilizer. A total of 11,894 tons of nitrogen was purchased as aqua ammonia in 1956. This represents 57 per cent of the total nitrogen purchases and an increase of 21 per cent over the 9803 tons purchased in 1955.

Studies have been continued to determine the efficiency of aqua ammonia applied in irrigation water (Figure 1). Field studies indicate that good water distribution is desirable in order to obtain a good distribution of ammonia, but in some instances a fair distribution of ammonia has been obtained with a poor distribution of water. Every effort is being made

to improve the quality of irrigation to ensure the future of fertilization in irrigation water.

Injection applications have expanded until now many plantations carry aqua ammonia on planting machines, replanting tractors, and ratooning subsoilers (Figure 2).

Rates of nitrification of injected ammonia were studied on eight additional soils ranging in pH from 4.4 to 7.9. The results confirmed those reported last year in showing high volatilization losses only in alkaline soils, and then only with high rates of application—200 pounds of nitrogen per acre.

The efficiency of aqua ammonia appears low when it is injected in wet soils in the cold winter months.



Figure 1. Application of aqua ammonia in Juice Quality Experiment at Kahuku Plantation Company. Studies are continuing on the distribution of aqua in irrigation water.

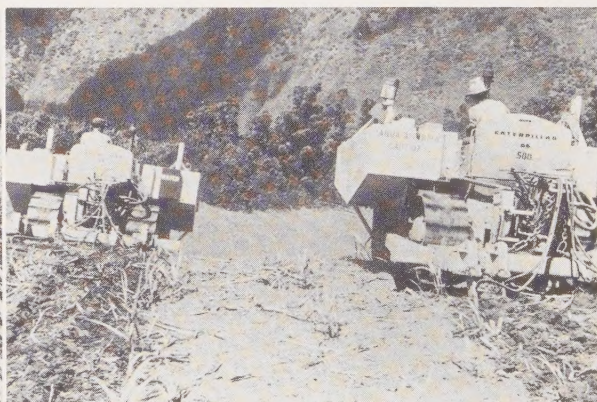


Figure 2. Aqua ammonia injection in ratoons at Honokaa Sugar Company. Injection of aqua ammonia has expanded rapidly on the unirrigated plantations in 1957.



Figure 3. The effects of aqua ammonia and DD, separately and in combination, on the growth of sugarcane plants. (37-1933, 18 weeks old. Pathology Plot. Test installed 9/14/56.)

In cold, wet soils, rates of nitrification are slower. Under extreme anaerobic conditions, aqua ammonia

remains as such in the injected band, and the cane suffers from a lack of oxygen and nutrients.

EFFECTS OF FUMIGANTS ON NITRIFICATION OF AMMONIA

Results of laboratory tests by the Pathology Department indicated that the soil fumigants DD (40 GPA), EDB (8 GPA), Telone (40 GPA), and S-1283 (8 GPA) were similar in their effects on the nitrifying bacteria, as nitrification of NH_4OH or $(\text{NH}_4)_2\text{SO}_4$ added to the soil was completely inhibited for at least four weeks. In the presence of the fumigants, approximately 20 weeks were required for the complete nitrification of the added ammonium (500 parts nitrogen per million parts soil), whereas in the absence of the fumigants, practically all of the added ammonium was nitrified in eight weeks. BBC (3 GPA) was found

to be least toxic to the nitrifying bacteria, no complete inhibition of nitrification being observed.

Fumigation with DD (40 GPA) and EDB (8 GPA) immediately following application of aqua ammonia (150 pounds nitrogen per acre) to the center of furrows apparently aided the maintenance of the nitrogen supply to 37-1933 plants grown therein for at least 18 weeks (Figure 3). BBC (3 GPA) was the least effective of the three fumigants tested. Plants in plots receiving nitrogen plus fumigants remained green longer and made better growth than plants in plots receiving the nitrogen or fumigants separately.

AERIAL FERTILIZATION EXPANDS

The airplane continues to be an important tool in the application of fertilizer. Its use is expanding, based on the response to extra fertilizer applied for continued growth during the second season. With heavier amounts of fertilizer being applied earlier in the crop to take advantage of the cheaper costs of nitrogen as

aqua ammonia, it becomes increasingly important to be able to predict accurately the requirements for a normal second season's growth.

Air fertilization pattern studies continued in cooperation with Murrayair Limited. Modifications in the fertilizer distributor were made in an attempt to

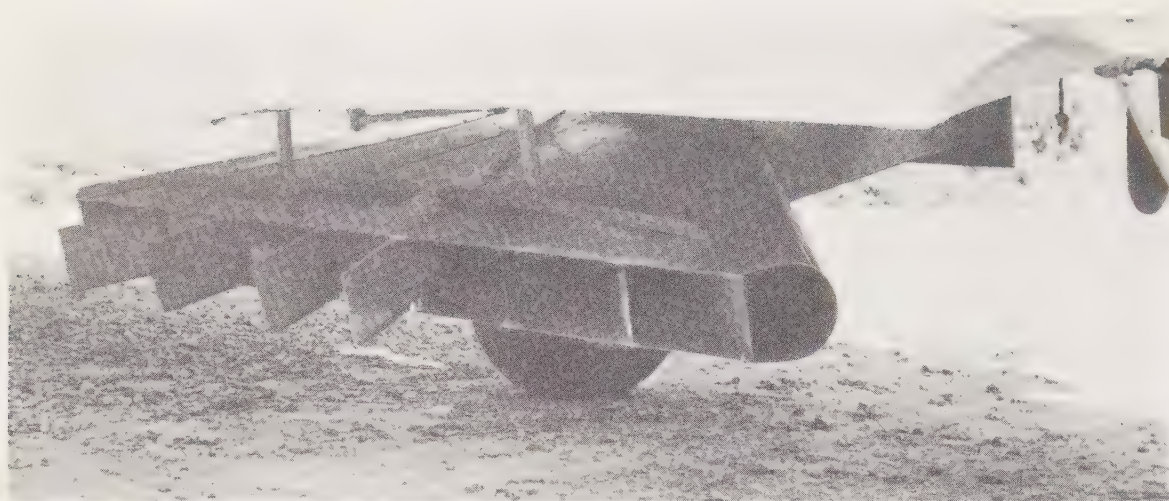


Figure 4. Modifications to the seven-slot airplane fertilizer distributor include vanes, attached as defectors on the slots at the left of the plane. The side openings are air scoops, intended only to aid in spreading the materials. This development by Murrayair Limited has greatly improved the pattern of fertilizer application. Previously, some streaking of application could be noted infield by the color response of the sugar cane. Such streaking has been reduced to a minimum by improvement in distributor design. Distributors are also being tested in which a portion of the bottom of each slot has been removed. Preliminary results look promising.

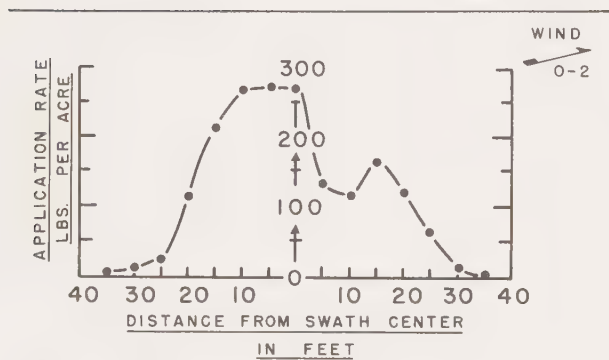


Figure 5. Cross section of fertilizer application pattern by airplane recorded prior to modification of the distributor. Note heavy application at the left side of swath with a deficiency on the right side. This pattern is caused by rotation of the propeller and a deflection of the fertilizer to the left. Adjacent swaths flown in both directions would give a high and low cross-sectional pattern. Olaa Sugar Company. Stearman plane RL216 OM 7-slot distributor flying 80 to 85 mph, 25 feet above cane, applying Granular Mix No. 4.

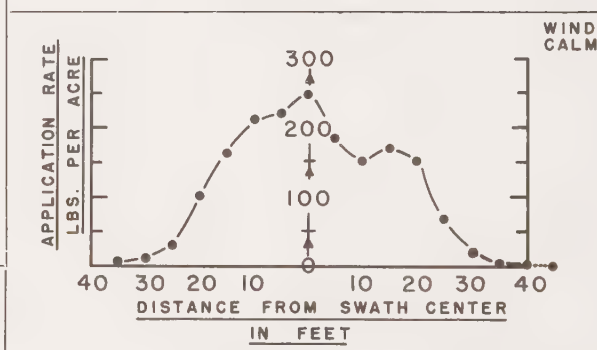


Figure 6. Cross section of air fertilization pattern following modification of the distributor shows a relatively uniform cross-sectional pattern. Part of the fertilizer had been deflected to the right side of the plane. A slight deficiency still exists, but adjacent swaths gave a relatively uniform pattern. This proved to be the case when the cross section of multiple swaths was measured. Olaa Sugar Company. Stearman plane RL216 OM 7-slot distributor with vanes in slots 2, 3, 4 and 5, flying 80 to 85 mph, 25 feet above cane, applying Granular Mix No. 4.

overcome infield streaking of fertilizer that resulted in alternating strips of light and dark green sugar cane.

The major modifications made to the distributor are shown in Figure 4. The cross sections of the application patterns before and after modification are shown in Figures 5 and 6.

Prior to the installation of deflector vanes on the

slots at the left of the distributor, the propeller slip stream carried an excess of the fertilizer to the left side of the swath. By installing deflector vanes, part of this material was forced back to the right to make a more uniform application. Studies are continuing with other distributor designs to further improve the application.

TRACE ELEMENT STUDIES SHIFT TO SOIL

After three years of analyses of sugar cane for trace elements, plant composition, with few exceptions, has not proved particularly effective in diagnosing deficiencies. Comparisons of field cane samples with deficient plants grown in nutrient culture show that levels of the principal trace elements are far above the minimum required.

When the quantitative trace-element analyses pro-

gram was initiated in 1950, soil analyses were scheduled along with plant analyses. The necessity of concentrating the trace elements from soils by organic precipitation methods led to a major effort on plant analyses. The 8-hydroxy quinoline-tannic acid method, used at Saratoga Labs, Inc., was costly in time per analysis. This year, however, a return to soil analysis has been made in an effort to obtain leads for field tests.

LEACHING LOSSES OF NITROGEN AND POTASSIUM STUDIED

Leaching losses of nitrogen were considered high for many years. Plantation fertilizer practices were adjusted to apply smaller amounts early and the rest after the cane was waist high. Studies in recent years have indicated that leaching losses are small in crops with extensive root systems.

Lysimeter tests have been made with four principal sugarcane soils, namely, (1) an acid hydrol humic latosol from Onomea Sugar Company, (2) an acid low humic latosol from Waialua Agricultural Company, Ltd., (3) a neutral hydromorphic soil from Ewa Plantation Company, and (4) an alkaline regosol from Hawaiian Commercial & Sugar Co., Ltd. Leaching losses of nitrogen were negligible in all soils where cane was growing, with the exception of the low humic latosol from Waialua. The cane in the Waialua

soil grew slowly at first and its root system was not effective in recovering the applied nitrogen, either from aqua ammonia or ammonium sulfate. In the pots without cane growing in them, the leaching losses were high. The leaching losses appeared about equal for the two forms of nitrogen used (Figures 7 and 8).

Waterlogging inhibits nitrification. Nitrification was completely stopped, even after 43 days of storage in a waterlogged condition (Figure 9). The pH of this hydrol humic latosol remained constant, and there was no loss of applied ammonia. Samples kept in a moist condition showed nitrification to proceed rapidly. The pH values dropped with the corresponding decreases in ammonia and increases in nitrate nitrogen.

Leaching losses of potassium were low in the soils

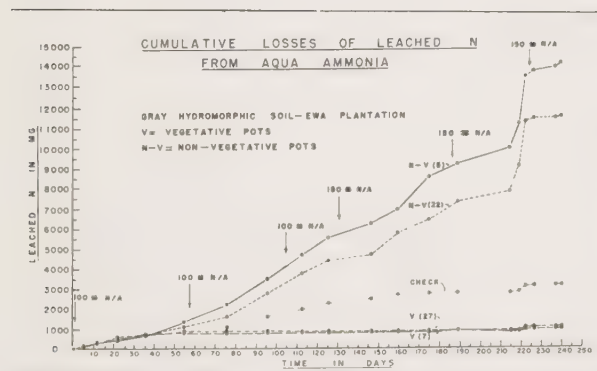


Figure 7

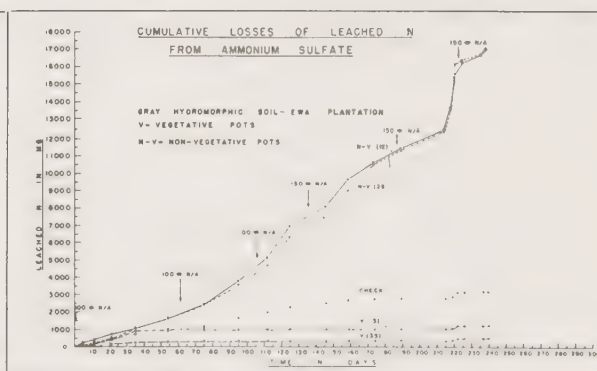


Figure 8

EFFECT OF WATER LOGGING ON NITRIFICATION

OF AQUA AMMONIA

HYDROL HUMIC LATOSOL HILO SUGAR Co.

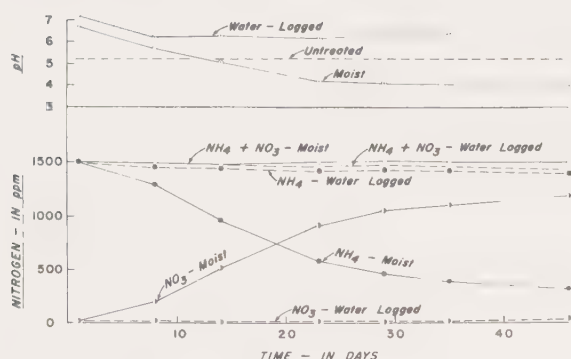


Figure 9

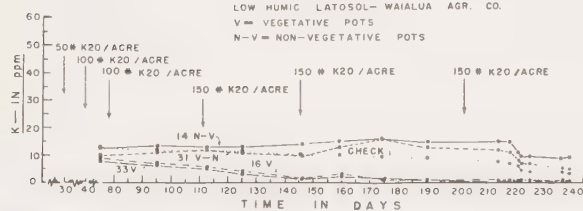
Figure 10

EFFECTS OF SUGARCANE ON LEACHING LOSSES OF POTASSIUM

LOW HUMIC LATOSOL- WAIALUA AGR. CO.

V = VEGETATIVE POTS

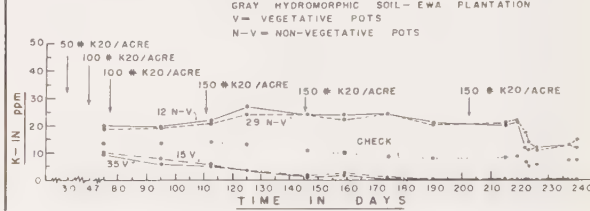
N-V = NON-VEGETATIVE POTS



GRAY HYDROMORPHIC SOIL- EWA PLANTATION

V = VEGETATIVE POTS

N-V = NON-VEGETATIVE POTS



with a higher percentage base saturation: low humic latosol from Waialua and gray hydromorphic soil from Ewa (Figure 10). In the acid, highly-leached hydrol humic latosol from Onomea, the leaching losses were negligible for the first 21 weeks, but were very high during the next 12 weeks or until most of what was applied had been leached out (Figure 11). The surface applied potash moved slowly downward and eventually reached the two-foot depth where it was removed in the drainage waters. The losses were negligible in the vegetative pots, and were nil after an effective root system had been established.

These data show the importance of proper placement of fertilizers in young cane. Placement near the zone of maximum concentration of roots should minimize leaching losses. The data emphasize the importance of delaying broadcast applications by airplane until the cane's root system has extended into the center of the interrows.

EFFECTS OF SUGARCANE ON LEACHING LOSSES OF POTASSIUM

HYDROL HUMIC LATOSOL- ONOMEA SUGAR CO

V = VEGETATIVE POTS

N-V = NON-VEGETATIVE POTS

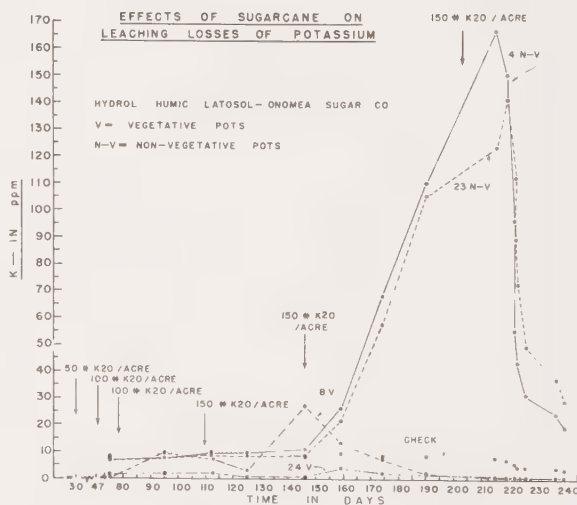


Figure 11

MAKIKI NITROGEN TEST INDICATES SIGNIFICANT EFFECTS

Variety 37-1933 was planted on May 25, 1955. The data from the May 1957 harvest, when the cane was 24 months old, are still being processed and evaluated. However, some interesting preliminary conclusions can now be presented.

The variables in the test were amounts and timing of nitrogen fertilization. Extensive tissue analyses were made at regular logging dates. All stalks of the two outside lines of each plot were dated at eight and 13 months so that growth could be measured in the periods 0-8 months, 8-13 months, and 13-24 months. This made possible a study of quality at harvest of the three classes of stalks: primaries, secondaries and suckers. Primaries are defined as all stalks with visible mature cane at eight months; secondaries had visible mature cane at 13 months; suckers grew entirely after 13 months. Furthermore, the primaries were divided into three dated sections, base, middle and top; and the secondaries into two sections, base and top.

Treatments included: four levels of nitrogen per acre (0, 100, 200 and 400 pounds), and four timings of applications ranging from all early to three-fourths at 13 months. Neither potash nor phosphorus was added since the Makiki soil is considered adequate in these two nutrients.

Quality Effects. Figure 12 summarizes the data on total solids at final harvest, grouped according to level of nitrogen. There was no drying off before harvest, except that the last scheduled weekly round of irrigation was omitted to dry the surface of the ground for harvest.

The following conclusions may be drawn from Figure 12.

1. Amount and timing of nitrogen have little or no effect on fiber.

2. Higher nitrogen improved quality as shown by the higher percentage of pol and lower non-sucrose juice solids.

3. Moistures of all stalks were approximately the same.

Yield Effects. Figure 13 summarizes the yields of: (1) outside lines; (2) total inside lines from end to end; and (3) mid-sections of inside lines which approach field conditions since all border effects are eliminated. The following tentative conclusions may be drawn:

1. Outside lines, bordering a wide alanui, yield at

least twice as much sugar as cane in the middle of the plots. This occurs at all levels of nitrogen. The effect is very striking at zero nitrogen where the outside lines can draw on a large area of soil for naturally available nitrogen.

2. Under the conditions of this experiment, variety 37-1933 needs more than 200 pounds of nitrogen per acre for maximum yield.

3. There is no evidence for improvement of yield by any system of delayed application. In fact, the overall average favors early application. For example, with 200 pounds of nitrogen per acre which limits the yield, top efficiency resulted from a single application within 30 days after planting. This would indicate that weekly irrigation did not cause leaching losses.

Age Effects. Table 1 summarizes the quality of juices expressed from the six stalk classes. A1, A2, and A3 are, respectively, the bottom, middle and top of the primaries as defined above; B4 and B5 are, respectively, the bottom and top of the secondaries; and C6 is the entire sucker stalk.

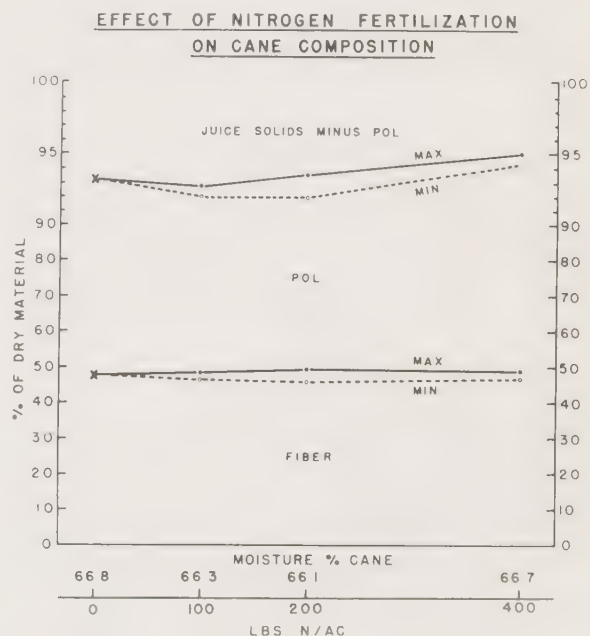


Figure 12. Distribution of cane solids at 24-month harvest of Makiki nitrogen test. The maximum and minimum values come from the timings of fertilizer application. Data from the outside lines only.

EFFECTS OF AMOUNTS AND TIMING OF NITROGEN FERTILIZATION ON POL YIELDS

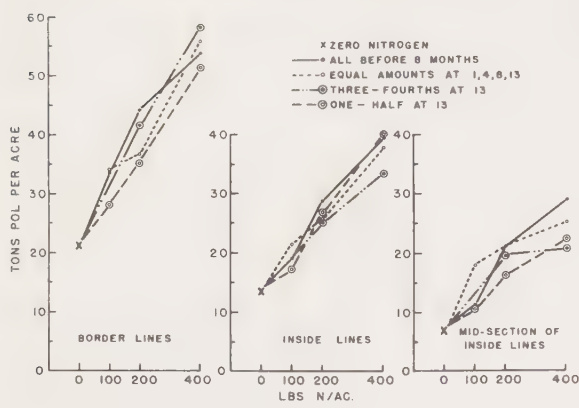


Figure 13. Yields, at 24 months, of cane from border lines, inside lines with end effects, and mid-section of inside lines from which all border effects are eliminated.

The following tentative conclusions are drawn from Table 1.

1. The primaries (A) have passed their prime and are deteriorating in quality. The effect is most apparent in the basal portion.
2. The secondaries (B) are in prime condition.
3. The suckers (C) have reached a high degree of development and are superior to the primaries.

TABLE 1

Juice Figures of Dated Sections of Stalk at Harvest
Averages of 12 Plots

Sections	Ref. Solids	Pol.	Purity
A1	21.42	17.74	82.80
A2	21.19	18.01	85.04
A3	20.41	17.28	84.71
B4	21.93	20.31	92.65
B5	20.81	18.73	89.98
C6	19.91	17.66	88.67

SOIL ANALYSES PROVIDE IMPORTANT DATA

Soil analyses have continued to play an important role in determining the amounts of phosphate and potash fertilizer to apply at the start of the crop. Nearly 4000 samples from most of the 27 plantations were analyzed in 1957. Increasing requests for pH, calcium and magnesium analyses indicate the current interest in liming.

Due to extreme differences in bulk density of Ha-

waiian soils, the results are now expressed as pounds per acre foot, based on the p.p.m. in the sample and the volume weight of the soil. Below 25 pounds phosphorus per acre foot, response is practically certain. Above 45 pounds, significant response has never been obtained except in cases of restricted root growth. For potassium, response is practically certain below 200 pounds and has not been obtained above 300 pounds.

LIMING ON THE INCREASE

The use of lime has expanded on the highly-leached soils of the Hilo and Hamakua coasts and on windward Kauai. Laupahoehoe Sugar Company adopted its use on all middle and mauka fields scheduled for plowing and planting. This year, approximately 800 acres received an application of one ton per acre.

Additional calcium tests were harvested this year. The results support the previously defined critical level of exchangeable soil calcium at 100 p.p.m. for the low volume-weight soils.

The tentative critical level of sheath calcium, established from earlier tests at .15 per cent, appears to be satisfactory. Only four calcium tests in which 8-10 stalk samples were collected have been harvested to

date. The adequate level for 8-10 Ca appears to be .06 per cent.

Two magnesium tests were harvested this year. Both tests failed to show response to treatment, even though the exchangeable Mg in the tests were 50 and 30 p.p.m. In the test installed in the soil with the lower Mg reserves, differences in growth were observed during the boom stage, but failed to carry through to harvest. The magnesium levels in both the sheath and 8-10 stalk showed increases in composition with increasing magnesium applications (0, 100 and 200 pounds per acre). On the basis of these two tests, a sheath level of .1 per cent and an 8-10 level of .05 per cent appear adequate.

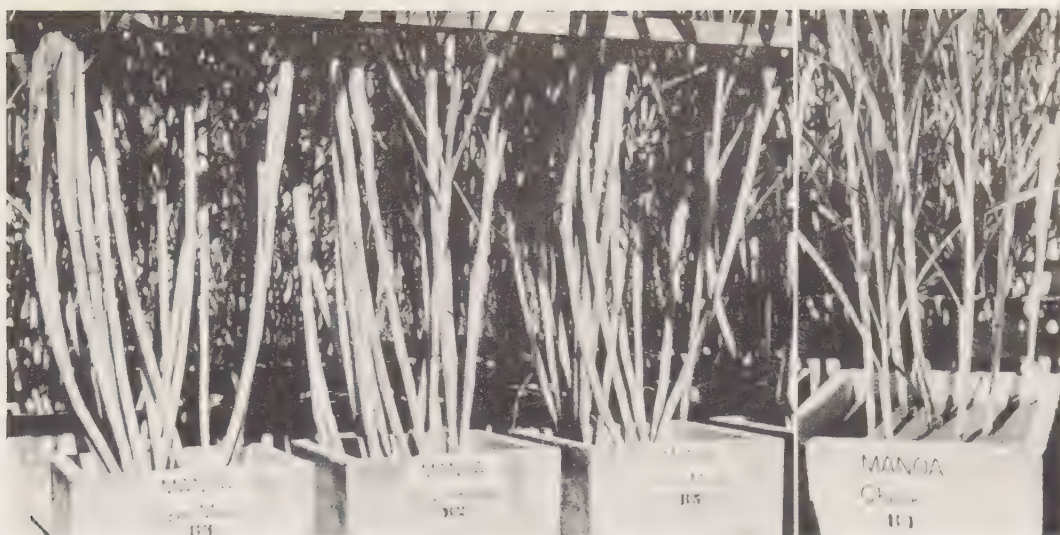


Figure 14. In this Manoa soil of pH 5.0, raw rock phosphate, when mixed with the soil, is seen to be about as effective a source of phosphorus as superphosphate.

EFFECTIVENESS OF RAW ROCK PHOSPHATE

Preliminary results from a pot test at Makiki comparing raw rock and superphosphate, both banded and mixed, on acid soils of widely varying pH are summarized below. The soils employed were a Kahuku soil

(pH 4.0), a Manoa soil (pH 5.0), and a Kipapa soil (pH 6.0). All three soils were extremely deficient in phosphorus as shown by Truog analysis. Phosphate fertilization was at the rate of 400 pounds P_2O_5 per acre.



Figure 15. Summer drought in unirrigated fields at Grove Farm Company. Cane, in fields that had received rock phosphate broadcast and were deep-plowed, showed little evidence of slower growth.



Figure 16. Root system extending throughout the soil to a 22-inch depth and then following channels to deeper depths where phosphate had been released behind the subsoiler shank in four outlets from 24 to 42 inches. Note one of the phosphate bands and the concentration of roots in it.

The crop was harvested at the age of 12 months.

Response to phosphate, as measured by the weight of millable cane per pot, was in every case very large. Yields in treated pots ranged from five to 10 times those in the respective check pots.

Raw rock phosphate was consistently more effective when mixed with the soil than when banded with the seed. The difference was most pronounced at the highest pH (Figure 14).

At the two lower pH's, superphosphate was more effective when mixed with the soil than when banded. At the highest pH, the two placements were equal.

Superphosphate-banded outyielded rock phosphate when similarly placed at all three pH's, the difference in favor of the soluble phosphate increasing with pH. Thus at the lowest pH the gain was slight, about 35 per cent at the intermediate pH and over 100 per cent at the highest pH level.

When superphosphate-banded is compared with rock-phosphate-mixed, a very different picture is presented. Under these conditions rock phosphate outyielded superphosphate at pH 4.0. At pH 5.0, there was a slight gain for superphosphate, while at pH 6.0 the yield from superphosphate exceeded that from rock phosphate by only about 15 per cent. Under the conditions of the test, rock phosphate when mixed with the soil proved an effective source of phosphate to all three levels of pH.

These results confirm the recommended practice of applying large quantities of raw rock phosphate broadcast prior to deeper plowing at the Hilo and Hamakua coasts and windward Kauai (Figures 15 and 16).

POTASSIUM DEFICIENCY AFFECTS TRANSLOCATION OF CARBOHYDRATES AND PHOSPHORUS

Following the usual technique of feeding radioactive carbon (C14) by photosynthesis, the translocation of photosynthate was then measured by observing its disappearance from the leaf. The results of such an experiment with a potassium deficient plant are summarized in Figure 17.

It is readily seen that potassium deficiency reduces the rate of loss from the leaf. Another point of interest is the greater rate of translocation during the day than at night. These results correspond in full with those reported in the 1956 Annual Report for effects of climate and translocation.

At the same time that C14 was fed to the leaf, P32 was added to the culture solution and its rate of upward movement determined. The results given in Table 2 show that the potassium deficiency also reduced the upward translocation to about the same de-

TABLE 2

Series	Downward Movement of C14	Upward Movement of P32
Control	1.27 cm/min.	1.9 cm/min.
-K	0.9 cm/min.	1.1 cm/min.

gree as the downward. Another point of great interest is the fact that the linear rate and translocation of organic matter from the leaf is of the same order of magnitude as the upward movement of an inorganic nutrient.

Other interesting observations about the utilization of phosphorus by the sugarcane plant are:

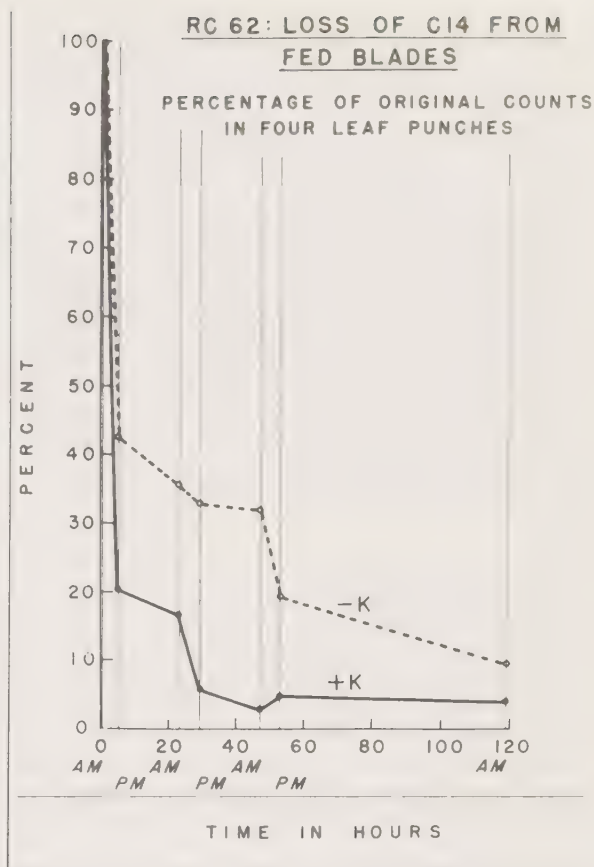
1. In leaves and roots, plants deficient in potassium accumulate large quantities of inorganic P; the amount of organic P remains about the same as in the controls.

In the stem, the reverse was found. The control plant contained 58 per cent inorganic P, the K-deficient plant only 22 per cent. Total P was only 10 per cent higher in the latter.

The most striking difference was found in the roots, where 95 per cent of the P was inorganic in the K-deficient plant, compared to 80 per cent in the control.

2. When P is first taken up by a cane root, it is found in an organic compound which has not been identified. It is probably not adenosine triphosphate (ATP). Hexose phosphates were also found even at the shortest times used.

Figure 17. The rate of movement of photosynthate from the leaf is reduced by potassium deficiency.



PHOTOSYNTHESIS SECRETS STUDIED

Photosynthesis with C14 (radioactive carbon) has thrown more light on the first compound produced in the sugarcane leaf. Conclusions from two experiments are:

1. In a paper on "PGA and Photosynthesis in Sugar Cane" presented at the February 1957 meeting of the Hawaiian Academy of Science, it was shown that sugar cane, unlike some other plants, does not make

phosphoglyceric acid (PGA) as its first product of photosynthesis.

2. By including radioactive carbonate in the alcohol used for killing a photosynthesizing cane leaf, photosynthesis time was made as short as is possible. Only free malic acid was found to be radioactive, showing that this is the earliest stable compound formed by photosynthesis in cane.

RADIOACTIVE SULFUR USED FOR FIRST TIME ON CANE

Some preliminary work with radioactive sulfur (S35) brought out the following interesting facts:

1. Radioactive sulfur was followed chromatographically for the first time here. Three hours after addition to the culture solution, activity was found in the leaves. This is a transport velocity of about one cm. per minute. Activity in the leaf increased slowly for four days, then more rapidly until harvest at 71 days.

2. Nearly all of the sulfur is found in protein. On hydrolysis, the amino acids, cystine and methionine, were found to be radioactive.

3. In the leaves, in addition to protein, sulfur was found in an alcohol-soluble compound which has not been identified. It may possibly be thioctic acid.

4. Very little inorganic sulfur was present in any part of the plant.

CROP LOGGING COMPARISONS

A total of 41 fertilizer experiments was logged during 1957 to correlate plant composition with yield data. The recommendations made in the 1956 report are supported by the facts accumulated during this year.

The crop log and stalk log have, in general, been less effective in predicting requirements for optimum yields in many sections of the industry this year. A ceiling imposed by climatic factors during the growth of the 1957 crop has resulted in lower sugar and cane yields, while the logs have been comparable to those of former years when higher yields were realized.

JUICE QUALITY BEING EXPLORED

Interest in juice quality has increased with the higher rates of fertilizer now being used. An analysis of the Amounts of Nitrogen tests over the last three five-year periods showed conclusively that higher nitrogen fertilization resulted in higher cane tonnage, but in 27 per cent of the tests, the higher nitrogen resulted in significantly poorer juice quality.

The Departments of Agronomy and Genetics, recognizing the effects of heavier fertilization on juice quality, promoted the installation of Group Test

Sampling studies were expanded during the year. Studies were initiated to determine the proper number of stalks required for a representative sample for sheath, 8-10 and basal sections.

Data collected from a nine-month-old crop of variety 37-1933 at Oahu Sugar Company, Ltd. indicate that nitrogen in the leaf, 8-10 stalk, and basal stalk, is reasonably well measured by a five-stalk sample. However, nitrogen and the other nutrients (potassium, total sugars, reducing sugars and sucrose) were much less precisely measured by a five-stalk sample for all three tissues.

32 to check the response to higher levels of fertilization of the newer commercial varieties, such as 49-5, 49-104, 49-134 and 44-2772. A total of 10 tests on Hawaii has been installed to date.

The Departments of Agronomy and Physiology and Biochemistry promoted the installation of Group Test 33 as a further check on the effects of the amounts and timing of nitrogen applications on juice quality. A total of seven tests on Oahu has been installed to date.

PREHARVEST SAMPLES AND JUICE QUALITY

A study of preharvest samples at several plantations has shown promise for predicting a field's readiness for harvesting. At Olaa Sugar Company, Ltd., 8-10 stalk preharvest samples collected from fields logged for the 1955 and 1956 crops showed a relationship between the sucrose to reducing sugar ratio and juice quality.

The juice figures from representative five-foot sections of line were obtained with a Cuban A Mill.

The data in Figure 18 show a marked improvement in juice quality as the sucrose to reducing sugar ratio increases to four. Above four, no additional improvement in juice quality was apparent.

Periods of heavy rainfall during harvest masked all relationships between nutrient ratios, moisture and sucrose to reducing sugar ratios with juice quality. These data stress the tremendous losses in sugar recovery resulting from harvesting during adverse weather conditions. Sugar grown is never recovered,

and the productive capacity of large sections of fields is drastically reduced by the resultant compaction and puddling of the soils.

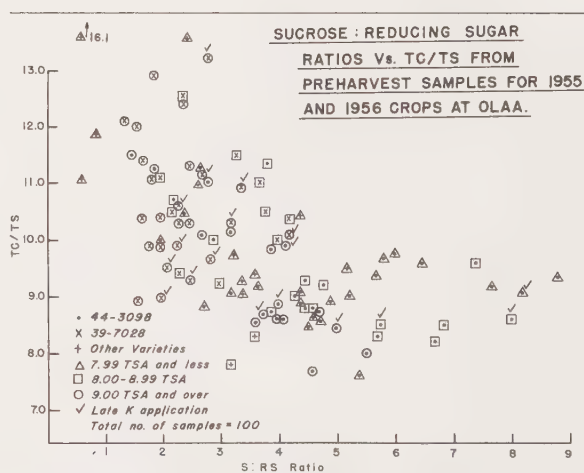


Figure 18

EXPERIMENT STATION, HSPA

Figure 19. Cloddy condition of a "reconditioned" roadway at harvest time, 25 months after damage had been done.



SOIL COMPACTION STUDIES

The effect of infield roadway compaction on sugarcane yields has been under investigation for the past several years.

Two tests were harvested this year as part of a study on the effect of various tillage sequences on reconditioning infield roadways compacted under wet soil conditions. The sugar per acre yields indicated a serious reduction for all tillage sequences in the roadway-grown plant cane over the ratooned cane in the field when harvested at an early age. The second test, however, was harvested at 25 months of age and failed to show any reduction in sugar per acre from the reconditioned compacted roadways. Reconditioning operations do not always result in a satisfactory seedbed (Figure 19).

Root growth studies were made in phosphorus deficient soil with layers compacted to different densities. Root growth was measured three times weekly for over four months (Figure 20). These studies indicated that with the soils in good physical condition, root development was enhanced by the application of phosphate fertilizer. Root growth rates through the compacted soil horizons were reduced when the density exceeded about 70 pounds per cubic foot. Roots failed to penetrate the compacted layer when the density reached 87 pounds per cubic foot in a low humic latosol. In a hydrol humic latosol, the daily growth rate became reduced at about 40 pounds per cubic foot, and ceased when the soil was compacted to 65 pounds per cubic foot.

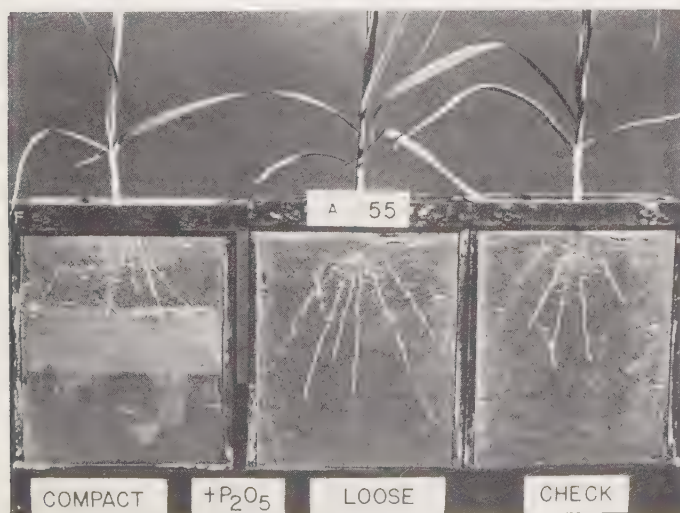


Figure 20. Daily root growth measurement of sugar cane in a phosphorus deficient soil. The box on the left has a compacted horizon which reduced root growth rates seriously. This box and the box in the middle received phosphate fertilizer at the rate of 800 pounds P_2O_5 per acre.



Figure 21. An underground view of a vertical chisel tilling a Hawaiian soil. Buckling action, shear plane development, plastic flow shear soil compression, and cohesive action are all visible.

TILLAGE OF HAWAIIAN SOILS

During the past year, principles of tillage were investigated at the National Tillage Machinery Laboratory in Auburn, Alabama, using three Hawaiian soils. Shear plane development was determined for these soils under various moisture and density conditions. Plastic flow conditions were also defined. Most of the soils of the irrigated plantations will exhibit plastic flow at usual field moisture and density below a depth of 12 to 14 inches when tilled with a rooter chisel or subsoiler. Soils on the unirrigated plantations will exhibit plastic flow at depths below six inches under usual soil conditions (Figure 21).

Draft determinations were made using various

tillage implements on these soils under many soil moisture and soil density relationships. In general, it was found that subsoiling required more power per unit of soil disturbed than did other tillage implements. The moldboard plow was by far the most efficient tillage implement tested under conditions when the soil would scour. An anti-hesive plastic has been introduced to the sugar industry which should allow very adhesive soils to scour. One of the anti-hesive plastics, Teflon, has been tested by the Pineapple Research Institute and appears to be a practical material to make possible the use of the very efficient moldboard plow as a tillage tool.

LIGHT INTENSITY AFFECTS CANE ANALYSIS

A shade transmitting 50 per cent of the light was erected over a 25- by 25-foot plot of variety 44-3098 after a good stand of ratoon cane was up. It received the same amount of water and fertilizer as the nearby control plot in full sunlight.

Stalks of equal size were taken from the middle of

each plot on July 16, 1957, when the cane was seven months old. Tables 3 and 4 show the pronounced effect of reduced light on moisture and sugars. Cloudy weather often reduces light to less than 50 per cent of possible radiation for prolonged periods. The data in Table 4 show that much of the usual log data can be

TABLE 3
Effect of Shading (50%) on 44-3098 at 7 Months

	Juice			Cane			
	Solids	Pol	Purity	% Fiber	% Moisture	% Pol	Pol Ratio
Shade	8.68	5.12	58.97	10.7	81.54	4.57	21.9
No Shade.....	12.18	9.15	75.11	11.7	77.54	8.07	12.4

TABLE 4
Field Cane Grown Under Full Sun and 50% Shade
Ratoon Crop: 6½ Months July 16, 1957
Expressed as % Dry Weight

Series	% Moisture	Reducing Sugars	Total Sugars	Sucrose
Joints 4-5 Shade.....	92.85	16.90	25.34	8.03
Joints 4-5 No Shade.....	91.36	15.58	24.19	8.14
Joints 8-10 Shade.....	86.93	14.19	39.07	23.65
Joints 8-10 No Shade.....	81.40	8.98	42.50	31.85
Basal Shade	80.21	8.08	45.45	35.50
Basal No Shade.....	74.73	2.21	51.35	46.69

altered so much by shade that the resulting canes are totally unlike the controls. They appear to be of different physiological age.

Cane growing in the low light intensity is of normal

size as measured by wet weight. But there has been insufficient photosynthesis to fill the joints with sugar. And the high moisture state has prevented the conversion of reducing sugars into sucrose.

GIBBERELLIC ACID ELONGATES CANE

Since the preliminary report of last year on gibberellic acid (GA), work has moved ahead as more plentiful supplies became available. The material being used is Gibrel, kindly supplied by Merck, Sharp and Dohme.

An experiment in which a stalk was treated with 10 mg. of the potassium salt of GA is illustrated in Figure 22. The joint, which was #4 at the date of application, is marked with a ribbon. It is observed that the rate of growth during the month following treatment was much greater than that of the untreated stalk.

In an experiment on growth effects of large doses of GA on individual stalks in the field, paired stalks of approximately equal size were selected, and one of them was injected with a single dose of 0.5 mg. of GA. The major increase in size was in the mid-section. The five new joints which developed from the growing point during the four weeks after injection were somewhat smaller in the treated plant than in the check. It would seem, therefore, that to maintain rapid

elongation, applications of GA must be repeated every month or six weeks.

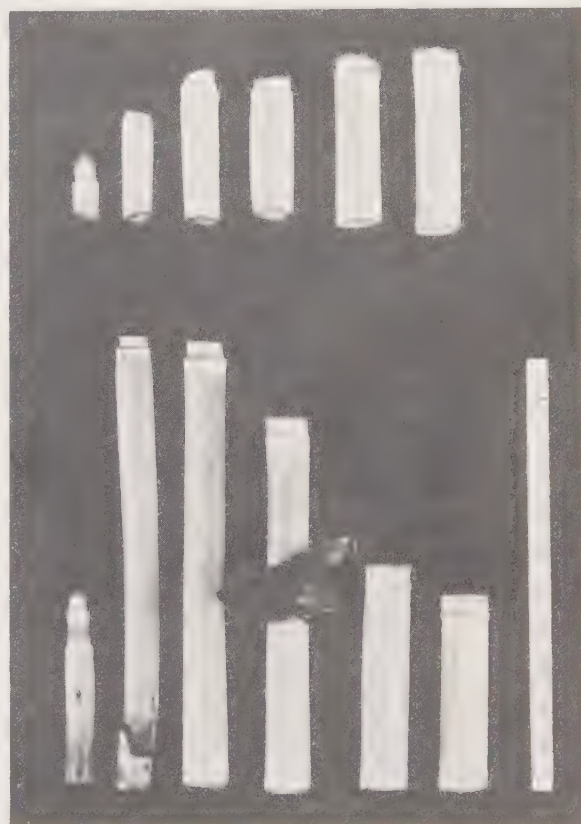


Figure 22. At the top, joints of check stalk, not treated with gibberellic acid, are shown. Below, 10 mg of the potassium salt of gibberellic acid were applied to the internode marked with a ribbon. This was the #4 joint at time of application. The three internodes to the left show increased growth in one month over the growth of the corresponding internodes of the check.

In another experiment, one mg. of GA was sprayed on the leaves of selected stalks. This also had the effect of greatly elongating the joints.

Tests of this kind show that large doses of GA can double the rate of elongation of healthy stalks of variety 37-1933, with a resultant increase in weight of about 50 per cent.

Other conclusions which can be drawn from the tests of the past year are:

1. No measurable effect can be expected after a single application of small amounts of GA (100 to 150 micrograms per plant) is sprayed on cane tops.

2. Smaller amounts of GA (40 micrograms) applied between the spindle and the next lower leaf will

cause marked increase in length of joints that will be elongating during the month following the application.

3. One milligram per plant applied as a spray has the same effect as smaller amounts applied in the dewlap.

4. When GA in solution is injected into the lower mature joints, the effects are very similar to those resulting from drops applied to the spindle.

Supplies of GA are now plentiful enough for field tests. Replicated plots at Makiki are now being treated at two levels of GA by two methods of application. These will be carried to harvest for complete records of yield, quality, etc.

THE SEALING OF CONCRETE TANKS

During the early part of the year, a request was made by a plantation manager that the matter of sealing concrete tanks for storing liquid fertilizer concentrates be investigated. The objective was to bypass metal tanks because of the corrosion which is bound to occur, both inside and outside, unless an effective inhibitor of corrosion is used in the solution itself, and a satisfactory, paint-like coating is applied to the outside of the tank. It was found that ordinary concrete will not withstand an appreciable hydrostatic head of water without leaking. It was also learned that some fertilizer concentrates carry, in solution, chemicals which attack concrete, in some cases producing a chalky, brittle effect, which weakens the tank.

A search was made for an inexpensive sealing agent which may be applied to concrete by spray gun

or brush, not only to seal the pores of the concrete against leaking, but to resist chemical action by dissolved fertilizers in the liquid concentrates. A preparation was found in New York City consisting of one of the modern silicones plus a synthetic resin, which the manufacturer claims will answer our problem. After conferring with the manufacturer in person, and later by correspondence, a second sealing compound was developed and forwarded for a continuance of the studies. The manufacturer is so confident that it will be superior to the material submitted earlier and found promising, that he has described his newest development as "Siliphane HSPA." This product will be given a thorough breakdown in the laboratory, using miniature concrete tanks which have been allowed to cure for about two months.

A NEW INHIBITOR OF CORROSION

A new inhibitor of corrosion, now under development in the Chemistry Department, may be found effective on several of the new fertilizer concentrates which are being manufactured on the mainland and

which may be prepared later by the fertilizer company in Hawaii. It is designed for use in the presence of free ammonia, corrosive nitrates, particularly calcium nitrate, and perhaps later, ammonium nitrate.

DISEASES

DISEASE RESISTANCE TRIALS INSPECTED IN FIJI

During the annual inspection in Fiji of the Hawaiian canes being tested against Fiji disease (FD) and downy mildew in cooperation with The Colonial Sugar Refining Company, Ltd., it was found that insufficient transmission of Fiji disease had occurred in the field tests to permit evaluation of the reaction of most varieties in the 1956-1957 trials. These varieties will be retested.

Methods for increasing FD transmission were discussed with pathologists in both Fiji and Australia. Some are of the opinion that FD is more prevalent on cane growing in sandy soils and that the disease is influenced by the time of planting. To secure further information on these two points, varieties of known

resistance and susceptibility to FD are being planted every two months during the next year on two soil types, heavy and sandy. Infective leafhoppers will be caged on the leaves of these plants in an effort to determine the importance of leafhopper populations to varietal susceptibility at different seasons of the year.

The uneven distribution of downy mildew on the variety Argus, the disease carrier, combined with the low amount of infection among the Hawaiian varieties, made it impossible to determine the reaction of all varieties in the 1956-1957 trials. These varieties will be retested. The results of the 1955-1956 tests were highly satisfactory.

MOLOKAI QUARANTINE

Periodic inspections of all canes under greenhouse and field quarantine were made in cooperation with other members of the Quarantine Committee. One lot of 23 introduced canes, having completed quarantine, was released in October 1956 for planting at the substations. Another lot of 22 canes was planted in the small quarantine house in November 1956. This

lot was imported through the USDA.

No symptoms of any disease foreign to Hawaii were noted on the canes while under quarantine. All cuttings were given the long hot-water treatment (50° C. for 2 hours) prior to their release from Molokai, as this is the best treatment known to guard against the introduction and spread of disease.

DISEASE REVIEW FOR 1957

Red Rot

Glomerella lucimaria

Red rot has spread rapidly during the past year and has caused serious losses in certain plantation fields of 38-2915 on Kauai, Hawaii, and Oahu. Since the variety 38-2915 occupies some 41,800 acres and is highly susceptible to the disease, red rot presents a serious problem to the industry. Losses up to and, in a few cases, exceeding four tons of sugar per acre have been estimated.

In April 1957, 10 stalks of each of 20 varieties were inoculated with the Lihue isolate of the red rot organism. The most susceptible variety was 38-2915, the most resistant was 37-1933 (Figure 23). Six

weeks after inoculation, many of the 38-2915 stalks were dead or dying.

The reactions of the varieties tested were:

38-2915	— —	46-564	= +
32-8560	+	48-546	+
37-1933	+	48-4605	+
39-7028	+	49-5	+
44-3098	+	49-134	+
39-3633	++	49-612	+
38-4443	= +	50-723	= +
45-2120	= +	51-4187	++
39-4753	+	51-4336	+
44-2772	+	50-2746	+

Two additional red rot varietal tests were installed, one at the Lihue Variety Station and one at the

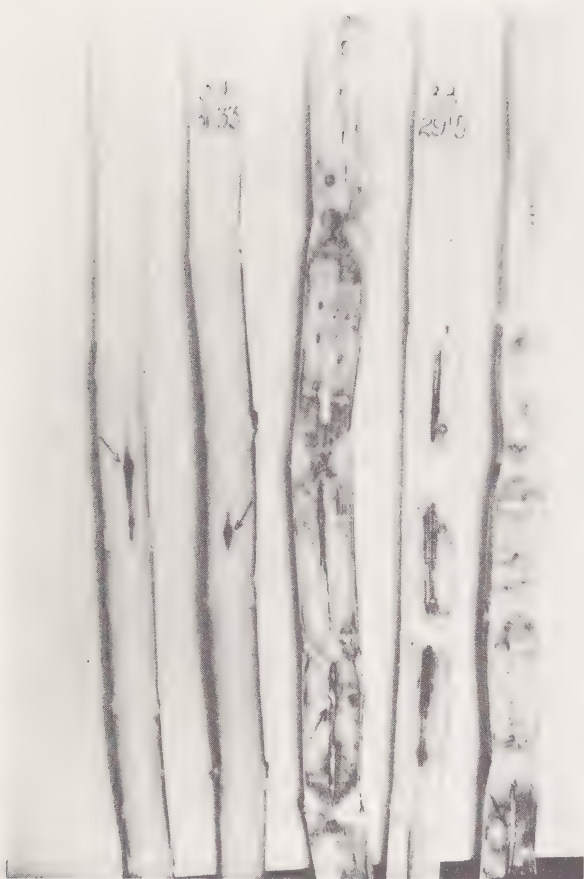


Figure 23. Varietal resistance (39-3633) and susceptibility (38-2915) to red rot disease are shown following artificial inoculations.

Pathology Plot, in which the more important varieties and those not already tested were included. A number of varieties have been tested against red rot on the plantations where they have shown outstanding promise.

The testing program must be given a high priority. The red rot organism isolated from each island is treated as a different strain and is not carried from one island or plantation to another (Figure 24).

The final control of red rot will be achieved by the use of resistant varieties, and first consideration should be given to those fields where the disease is most severe. Fields affected with red rot and approaching maturity should be harvested as early as possible to prevent further spread of the disease and further reduction in sugar.

In considering a possible field control of red rot with fungicides applied by plane as dusts or sprays, some 17 fungicides were tested against the red rot organism by the thread technique in the laboratory. The fungicides found to control the disease most effectively are: BSM-11 (phenyl mercuric acetate + potassium 2, 4, 6-trichlorophenate, 1:3200), phenyl mercuric acetate (1:1600) and Tin San (bis-(tri-n-butyltin) oxide, 1:800). The copper fungicides did not control the growth of the fungus at concentrations of one to 50.

Only a slight amount of injury was done to the leaves of 37-1933 and 38-2915 when BSM-11 at 1:3200 and PMA at 1:1600 accumulated in the

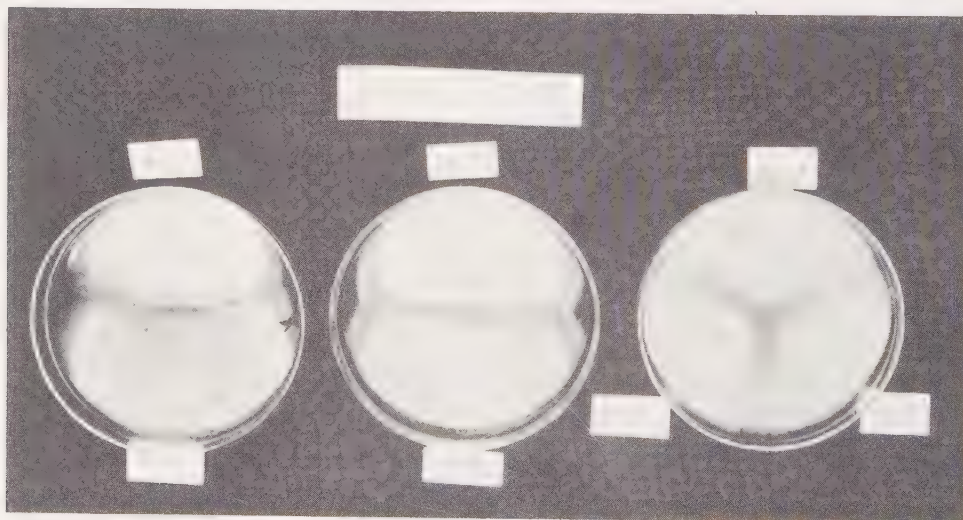


Figure 24. Pure cultures of the red rot organism isolated from affected 38-2915 from Kauai (K) and Oahu (W).

spindle when sprayed on actively growing plants. A greater amount of injury resulted from spraying with BSM-11 at 1:1600 and with PMA and Tin San at concentrations of 1:800.

However, this method of control does not appear practical. It is difficult to apply the fungicide and to maintain complete coverage of all plant parts. Rains wash the fungicide off, and the cost of treating large acreages is high. This was also true in the case of eye spot disease on H 109.

Transmission and Control of Chlorotic Streak

Chlorotic streak (CSD) was of considerable importance in low-lying areas on Hawaii. When first ratoons of healthy and diseased plants of 32-8560 and Trojan were grown together in water cultures, four of the eight healthy Trojan plants developed CSD. Further studies will be conducted under insect-free conditions before definitely establishing root transmission of CSD.

In 25 gallon drums, healthy and diseased plants of 37-1933 and 38-2915 were grown together in sterilized soil with and without nematodes. The healthy plants developed no CSD symptoms in the plant and first ratoon crops; in the second ratoons, all pots were watered twice daily, thus creating wet soil conditions, and leaf symptoms of CSD developed on healthy plants in one drum of 37-1933 and in two of 38-2915.

The hot-water treatment for controlling CSD is 50° C. for 30 minutes, or 52° C. for 20 minutes. The hot PMA treatment used by plantations for improving germination and controlling pineapple disease is 50° C. for 20 minutes in a 1:1600 PMA solution. The HPMA treatment was found to give good control of CSD.

Ratoon Stunting Disease

Ratoon stunting disease (RSD) was not found to be spreading in the Territory. The severity of this disease is much greater when canes are subjected to drought conditions. Losses in sugar yields from two varieties infected with ratoon stunting disease were measured when 37-1933 and 44-3098 were grown at Waipio under conditions of normal and subnormal irrigation. The reduction in yield for the varieties infected with RSD, when harvested at 25 months of age, was 14.7 per cent with normal irrigation (27 rounds), and 33.6 per cent for the longer interval (17 rounds).

No differences in the susceptibility of these varieties were evident in this experiment.

A test to determine sugar losses from 20 commercial and promising varieties affected with RSD was installed with cuttings from adjacent plots of healthy and diseased plants.

Disease-free areas of varieties which are being spread on the plantation should be maintained in order to control RSD.

Miscellaneous

Pineapple Disease. Subnormal germination of cuttings given the hot PMA treatment and planted under dry conditions was found to be caused by pineapple disease. It was likely that the PMA concentration of the solution became too weak to protect cuttings planted under adverse conditions. Also, a rapid drying of the cut surfaces of treated seed pieces causes a cracking of the tissues through which rot-producing organisms may enter. Where adequate soil moisture was present, treated (HPMA) cuttings germinated satisfactorily.

There is some evidence of differences in varietal susceptibility to pineapple disease which may explain differences in germination following the same treatment.

Mosaic Disease. The varieties 45-2608 and 48-4646 in a 40 x 40 planting at Waialua were found to be affected with mosaic disease. These are the first cases of the disease noted on the newer or commercial varieties for a number of years. It is suggested that these varieties be examined in other plantings for symptoms of mosaic. It was interesting to note that rather large plantings of corn were in the neighborhood; it is possible that the disease was transmitted to cane by the corn aphid *Aphis maidis* which lives normally on corn and on certain grasses in and about cane fields.

Leaf Scald. Only a few scattered cases of leaf scald were present and no outbreaks of the disease occurred.

The best insurance possible against losses by disease is to maintain at all times disease-free nurseries which have been developed from LHWIT seed. It is highly recommended that such areas be continued, or established immediately if not now in use. There is good evidence that the life of commercial varieties may be prolonged by planting only disease-free seed of the highest quality.

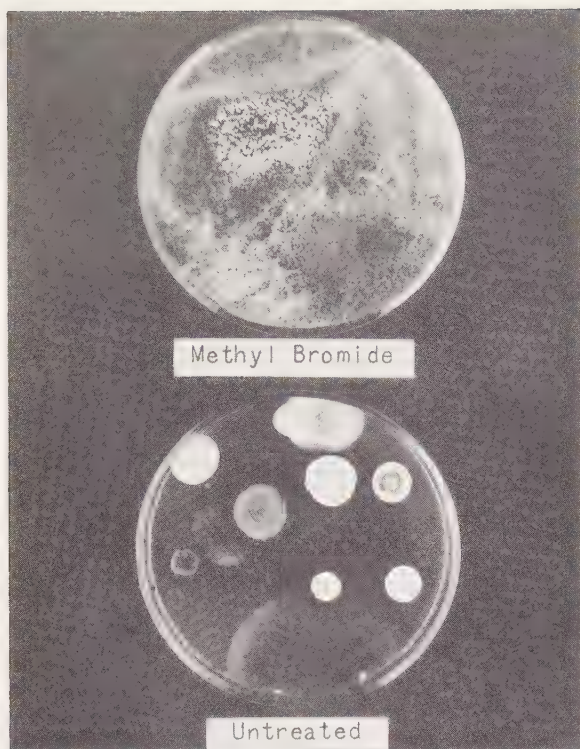


Figure 25. Changes in the types of fungi in soil resulting from fumigation with methyl bromide. Note the development on the agar plate of *Trichoderma* spp. from treated soil in contrast with miscellaneous types from untreated soil.

EFFECTS OF FUMIGANTS ON SOIL FUNGI

It was occasionally observed that the fungus flora of the soil is markedly altered as a result of fumigation. In the fumigated soils, *Trichoderma* spp. were found to be predominant, while in untreated soils, a greater variety of fungi were invariably found (Figure 25). *Trichoderma* spp. are known to be antagonistic to

some soil-inhabiting plant pathogens, for example, to *Pythium* and *Rhizoctonia*, but results of pot studies with several isolates of *Trichoderma* failed to indicate that they had stimulatory or inhibitory action on cane growth. Studies on the effects of the *Trichoderma* spp. on cane growth will be continued.

LABORATORY-SCALE CANE-PUMPING TESTS STUDIED

Since the early part of April 1957, contributions have been made to the studies on the control of deterioration of sugar in the laboratory-scale cane-pumping system at HC&S, Puunene, Maui. Counts of micro-

organisms (bacteria, yeasts, and molds) in the slurry have been made to obtain some idea of the relationship between numbers of microorganisms present and deterioration of sugar. The work is being continued.

NEMATODE RESEARCH RECEIVES SPECIAL EMPHASIS

The role of nematodes as a factor in yield decline continues to be the subject of an intensive investigation. Examination of nearly 4000 soil samples indicates that many plantation soils contain several species of nematodes which are considered serious pests of several crops elsewhere. Various greenhouse experiments have been established to determine the effect of

these pests upon the growth of sugar cane, and these studies are being supported by taxonomic and ecologic data.

Dr. Harold J. Jensen of Oregon State College joined the Experiment Station in August for a period of six months to assist in identifying parasitic species occurring in plantation soils, in determining the effective-

ness of fumigants for controlling nematodes, and in studying soil fumigation under field conditions.

Soil fumigation, when properly done, is an effective control measure for many nematode pests, and is an established practice in thousands of infested acres, according to Dr. Jensen. There are, unfortunately, many pitfalls that must be avoided if results are to be effective, and many of them vary with area or situation. In Hawaii, encouraging results of soil fumigation in some areas has spurred further investigations. In order to improve the efficiency of soil fumigation in sugarcane culture, a study is being made of the effects of soil preparation, new materials or new formulations of known materials, equipment and methods for application, and the relationship of levels of pest populations to time of treatment. As more information is obtained, soil fumigation may take its place as a recommended procedure for certain areas.

The results of field and laboratory studies for 1957 support those of 1956, and six nematode species considered in 1956 have been included in recent surveys. The best technique for pinpointing those areas where the greatest yield increases may be expected from soil fumigation appears to be the extraction and identification of nematodes from plantation soils. The 1956 survey of plantation field soils showed a great varia-

tion in population patterns. This has been true within a small field area in other crops, and is assumed to apply also to sugar cane.

The following fumigants and rates for their field application are suggested:

DD	40 GPA
EDB	8 GPA
Telone	40 GPA
BBC	3-4 GPA

The fumigation tests installed on different plantations in 1955 are being harvested and a summary of the results will be available towards the end of the year. In some areas, a definite yield response has been obtained from fumigation, while in others, response has been small or nil.

A power rig for applying fumigants was developed by the Field Engineering Department, cooperating with the Department of Pathology, and complete details are given under Mechanization. After certain mechanical adjustments were made, the injection unit operated quite satisfactorily. Some 12 tests were installed (under Group Test No. 36) on Hawaii, and row and broadcast applications of DD, Telone, EDB, BBC, and a combination of Telone and BBC, were made.

FACTORY

COLORED SUBSTANCES IN SUGAR CRYSTAL ISOLATED AND IDENTIFIED

The removal of the colored material present within the sucrose crystal presents the major problem in the refining of Hawaiian raw sugars. Very little information is available on the chemical composition of this coloring matter. A basic project was set up, therefore, with the objective of isolating, identifying, and tracing the source of this troublesome matter.

Using paper chromatography techniques, it has been found that the crystal contains a variety of organic impurities (Figure 26). Among these are glycosides, phenolic compounds, amino acids, polyhydroxy acids, reducing sugars, glucose polymers and degradation products of the sugars. Most of the substances possess color.

Application of electrophoresis has led to the identification of several of the individual compounds. Two colored bands migrate in opposite directions in an alkaline buffer. One is yellow, the other brown. Electrophoregrams are shown in Figure 27. From the yellow band, five colored substances have been resolved. These indicate the presence of naturally occurring plant pigments of flavonoid character.

The brown band contains amino acids and carbohydrate degradation products. This is probably indicative of the formation of compounds or complexes in the factory processing of the sugar.

Three amino acids have been identified. These are glutamic acid, aspartic acid, and tryptophan. All are normally present in the cane plant.



Figure 26. Column Chromatography Fractionator.

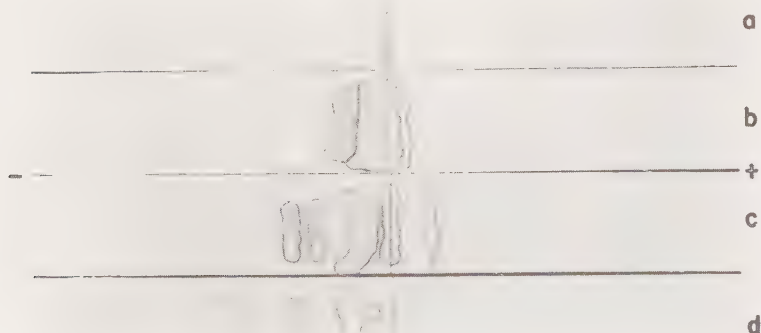


Figure 27. Electrophoregrams of crystal color. Fluorescent zones under ultraviolet light at (a) zero-hour, (b) one-hour, (c) two-hour and (d) four-hour electrophoresis.

NEW METHODS OF ANALYSIS DEVELOPED

Previous refinery methods of analysis of raw sugar for the quality factors of color, filterability, and grain size, were laborious and unsatisfactory indicators of refinability. Development and testing of new methods are under way.

A polaroid grain camera (Figure 28) has been designed as a factory instrument which will enable the pan operators to observe and record the grain size of each strike. Several of these cameras are being built for the plantations by the Experiment Station instrument shop.

Studies on grain size determination have shown that the old method gives values that are generally too low. A procedure making use of methyl alcohol instead of isopropyl alcohol gives more reliable results.

A rapid color method giving what is termed "affined color" has been developed. The procedure, which involves washing of the sugar with syrup in a centrifugal, gives figures more closely related to the color of sugar entering the high grade melt at the refinery than either the old raw color or crystal color.



Figure 28. HSPA Grain Camera.

LOW GRADE SEED HAS ADVERSE EFFECT ON SUGAR QUALITY IN FACTORY TESTS

A series of 18 tests conducted by 11 factories has shown that the use of low grade sugar for seeding commercial sugar strikes results in poorer quality sugar

than can be obtained by the use of shocking or slurry seeding techniques. The average figures for the tests are as follows:

Shock Seeding Comparisons					Slurry Seeding Comparisons				
No. of Tests	Method	Color		Filtration Rate	No. of Tests	Method	Color		Filtration Rate
		Affined	Crystal				Affined	Crystal	
13	Shock	4.9	3.3	77	5	Slurry	5.6	4.2	56
	Low Grade	6.8	4.6	72		Low Grade	8.2	6.1	53

PHOSPHATE TREATMENT INEFFECTIVE

Several factory tests demonstrated that addition of phosphate in economical quantities to mixed juice had

no appreciable effect on color or filterability of commercial sugars.

MILLING INVESTIGATION PROGRAM INITIATED

Projects relative to the milling of cane were started during the year. In the first of these, a study is under way on methods for controlling the feed of cane to the mill. Instruments have been installed on a tandem of the milling train at Oahu Sugar to record cane blanket height, knife and shredder power requirements, mill carrier speed, and top-mill roll movement.

Data from these will be used to devise a feed con-

trol system which is a prerequisite to studying mill performance.

Laboratory investigation of the fundamentals of juice extraction from the cane stalk has been directed first toward diffusion. Rate studies have demonstrated the importance of thermal killing of the cane cells in order to obtain rapid diffusion of sugar into maceration water.

ELECTRIC MEMBRANE DEMINERALIZATION PROGRAM CONTINUED AT PUUNENE

Operation of the Ionics demineralization unit at the Puunene factory of HC&S has continued throughout the grinding period. Work was devoted principally to a study of the buildup of anion membrane electrical resistance, which was found to be the critical problem last year. New anion membranes of the weak-base type, developed by Ionics for this use, were used during most tests. These membranes show little evidence of the type of permanent fouling found with the strong-base membranes. They do, however, have a higher initial resistance and are extremely sensitive to pH variations, so that rapid increases in resistance can occur at times. These membranes do not appear to offer a solution to the problem. In the meantime, work on defouling of the strong-base membranes indicates that there is a possibility of success.

A complete re-evaluation of the economics of the

process has been made. This is based upon the completed data from last year's operation which showed that on the average, 1.35 pounds of additional sugar were recovered for each pound of sulfated ash removed in the demineralization. Process economics are highly sensitive to prices of sugar and molasses, and the latter has fluctuated 400 per cent during the investigation. The evaluation also points out the effect of yearly increase in equipment costs, compared with a static price for sugar, in making any sugar recovery process less attractive each year. The Ionics process remains of economic value only if an average membrane life of one year can be obtained. At present, this is possible only with the cation membranes.

Ionics, Inc. is continuing to develop new and promising membranes and has made major advancement in stack design.

USE OF POLYELECTROLYTE ET-81 IN CLARIFICATION STANDARD PRACTICE AT MANY LOCATIONS

The polyelectrolyte ET-81 is now being used routinely to improve settling rates and clarity in many factories. It is particularly effective in the treatment of juices from cane grown in grey hydromorphic and alluvial soils which are the sources of the greatest amount of clarification trouble.

Unfortunately, ET-81 is not effective in juices from high rainfall areas which include most areas on the island of Hawaii. A constant search is maintained for

compounds which may be useful in these regions. During the year, laboratory tests on seven potential materials have been completed on juice from 18 different plantations.

Although some of the new materials give improved clarity, none has an appreciable effect on settling rate. The rapidly increasing number of new polyelectrolytes being developed, however, greatly enhances the probability of finding a useful one.

AMINO ACIDS DECREASE RATE OF CRYSTALLIZATION OF SUGAR. SALT MIXTURES HAVE VARIOUS EFFECTS

Both of the naturally occurring amino acids, aspartic acid and glutamic acid, lower the rate of crystallization of sugar from otherwise pure solutions. Although present in cane juice in relatively small quantities, these nitrogen compounds may exert a governing effect upon the crystallization of sucrose in the factory since concentrations of only 0.085 per cent caused a rate decrease of seven to nine per cent.

The effect of mixtures of salts on sucrose crystalliza-

tion rates continues to show unexpected results, as shown in Figures 29 and 30. Definite maxima occur with mixtures of magnesium chloride with calcium chloride, and potassium chloride with calcium chloride. The over-all picture to date is clear, however, in these respects. Potassium chloride and sodium chloride both decrease crystallization rates in practically all mixtures, whereas calcium chloride increases the crystallization rate.

CONTINUOUS SUGAR CENTRIFUGAL DEVELOPED AND TESTED

A "Mercone" continuous sugar centrifugal was studied at Waialua during two series of tests (Figure 31). The machine is a commercial-size unit, built by

Dorr-Oliver, Inc., following tests on a pilot model early last year at Oahu Sugar.

The machine employs a vertical conical screen, 16

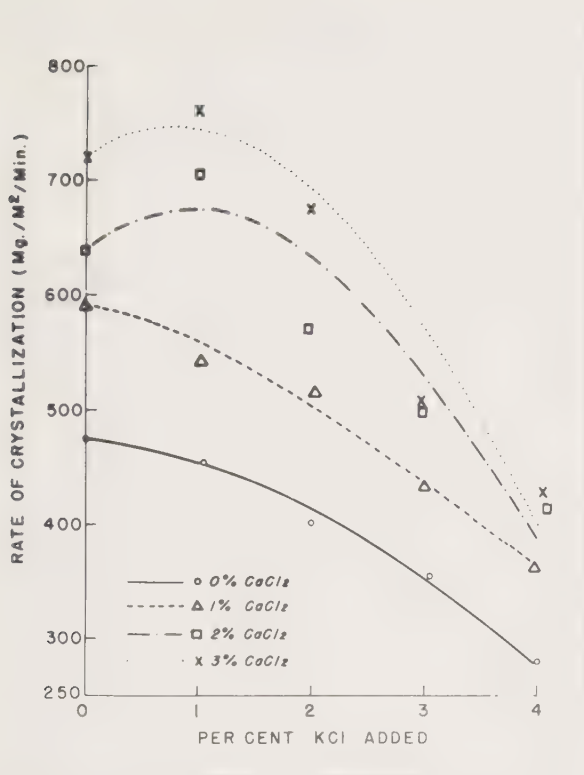


Figure 29. Effect of calcium chloride on the crystallization rate of sucrose in the presence of potassium chloride.

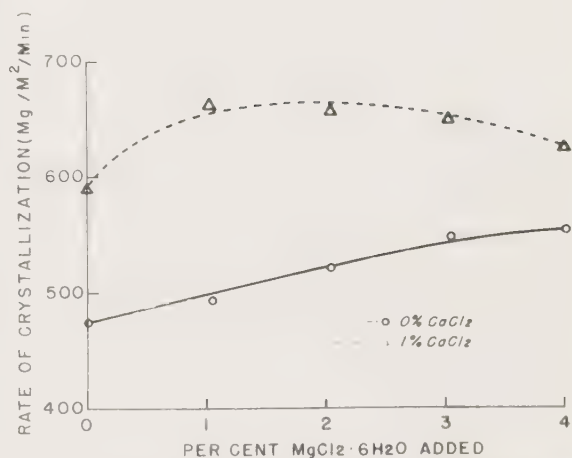


Figure 30. Effect of calcium chloride on the crystallization rate of sucrose in the presence of magnesium chloride.

Figure 31. The Mercone continuous sugar centrifugal.



inches in diameter at the large end, spinning at 2400 to 3200 rpm. Operating inside the screen is a helix which scrapes the sugar to discharge at the large end of the screen.

Test runs demonstrated that the centrifugal could handle massecuites up to 92 refractometer solids. Sugar with a pol between 96 and 97 without washing could be obtained at a rate of four tons per hour. With washing, pol as high as 98.3 was obtained.

The sugar from the machine contained a considerable quantity of pulverized sugar in the form of sticky

lumps. In order to eliminate these, the helix was re-designed with fewer flights, and a variable speed drive was installed on the helix.

Crushing of grain remained, however, and it was apparent that this was not due primarily to the action of the helix, but to impact on discharge. This is a characteristic of all continuous centrifugals. Design alterations to minimize this action will be taken. The machine is attractive in its ability to separate sugar from molasses with a minimum of power and investment cost.

THIRD YEAR OF CUTTER-WINDROWER *vs.* PUSHRAKE TESTS COMPLETED

The 1957 series of plots comparing the cutter-windrower with the pushrake were processed in standard milling runs at The Lihue Plantation Company, Ltd. These plots were ratoon cane from the first series of

plots in 1955. As in previous series, the milling and boiling-house recovery figures show no significant differences in cane quality or yield in the two methods of harvesting.

POL RATIO METHOD APPLICABILITY TO FACTORY CONTROL AND FIELD DISTRIBUTION SHOWN

Interesting data on the usefulness of the pol ratio method in factory control resulted from the cutter-windrower versus pushrake tests at Lihue during 1956. Cane samples were taken before and after the cleaner, stripped of trash and analyzed by the pol ratio method. Test plots averaged 326 tons net cane. Factory control figures were obtained in the usual manner and standard pol ratio procedure was followed.

Results obtained on a net cane basis were as follows:

Pol, before cleaner, pol ratio method.....	12.74
Pol, after cleaner, pol ratio method.....	12.46
Pol, after cleaner, factory control.....	12.67

Pol per cent net cane obtained by the pol ratio method and the factory control method are remarkably close on average results, indicating the possibility of using the pol ratio method to calculate cane weights when or where conditions preclude the use of usual methods, providing the additional cost is warranted.

An extensive program has been conducted at Kekaha Sugar Company, Ltd., using the pol ratio method for preharvest sampling. Although the results have not been used for field distribution, a comparison of data shows a good agreement between them and the routine method now used by the factory, based upon Cuban A mill samples.

FACTORY OPERATIONS FOR THE YEAR

Sugar production during the 1956 grinding season was 1,099,543 tons of 96 DA sugar. This established a record of more than one million tons per year for five successive years.

Crushing plants again set new records by grinding 85.1 tons net and 94.7 tons milled cane per hour with a calculated fiber milling rate of 4.5. This was achieved, however, with a sharp drop in milling performance as measured by extraction and milling loss. These averaged 93.9 and 4.9, respectively.

Cane quality, as indicated by pol in cane, was poorer than during any of the past seven years.

In percentages ground, the variety picture changed slightly, with 37-1933, 32-8560 and 32-1063 declining, and with 44-3098, 38-2915 and 44-2772 rising.

While processing plant results showed no great variation from recent years, the following are worthy of note: The purity of low-grade sugar reached a new high of 78.4, and the refractometer sucrose purity of molasses at 37.5 was the lowest since the adoption of a refractometer solids basis. The pol of commercial sugar of 97.65 was the highest since 1932, but the sugar averaged below standard quality with respect to grain size and color.

GEOPHYSICS

TSUNAMI OF MARCH 9, 1957

On March 9, 1957, a large tsunami originating in the Aleutian Islands swept Hawaiian shores (Figure 32) doing considerable damage, though, through good fortune and the operation of the Seismic Sea Wave Warning System, causing no loss of life. This tsunami is the third major one experienced since 1946. The frequency in this period does not seem abnormal, but the intensity does. The Geophysics Department cooperated with other institutions and individuals in recording data on the characteristics of this tsunami in accordance with a program intended to be set up for the International Geophysical Year under the general auspices of Scripps Institution of Oceanography and the local auspices of the Hawaii Institute of Geophysics.

Maximum observed heights to which the 1957 tsunami washed on the various islands were as follows: Kauai, 53 feet at Wainiha; Oahu, 30 feet at Kaena; Molokai, 25 feet at Waikolu; Maui, 15 feet at Waihee; Hawaii, 32 feet at Pololu. Damage was most extensive on the Wainiha-Hanalei coast on Kauai and the Waialua coast on Oahu. The patterns of both intensity and

damage were generally intermediate between the patterns for the 1946 and 1952 tsunamis, whose points of origin were, respectively, east and west of that for 1957. As in 1952, but not 1946, a considerable range of periods was recorded by tide gauges. Those recorded in Hawaii were 10 minutes at Nawiliwili, 13 minutes at Honolulu, 23 minutes at Kahului, and 18 minutes at Hilo. At Kwajalein, there was a period of three minutes, and at Guam, periods of 36 to 60 minutes. It is probable that these various periods are resonant modifications of the original waves, but it is uncertain whether local resonance simply selects periods from a broad underlying spectrum, or whether it actually alters the period from the fundamental one.

A number of wells' recorders indicated water level changes initiated either by the tsunami, the accompanying earthquake, or both. The tsunami records from these wells agree in general with the nearest tide gauge records so far as periods are concerned. The earthquake records consist generally of a four- or five-minute period, much longer than that of most earthquake waves and deserving of further study.



Figure 32. Third wave of the 1957 tsunami charging in to Kalihiwai.

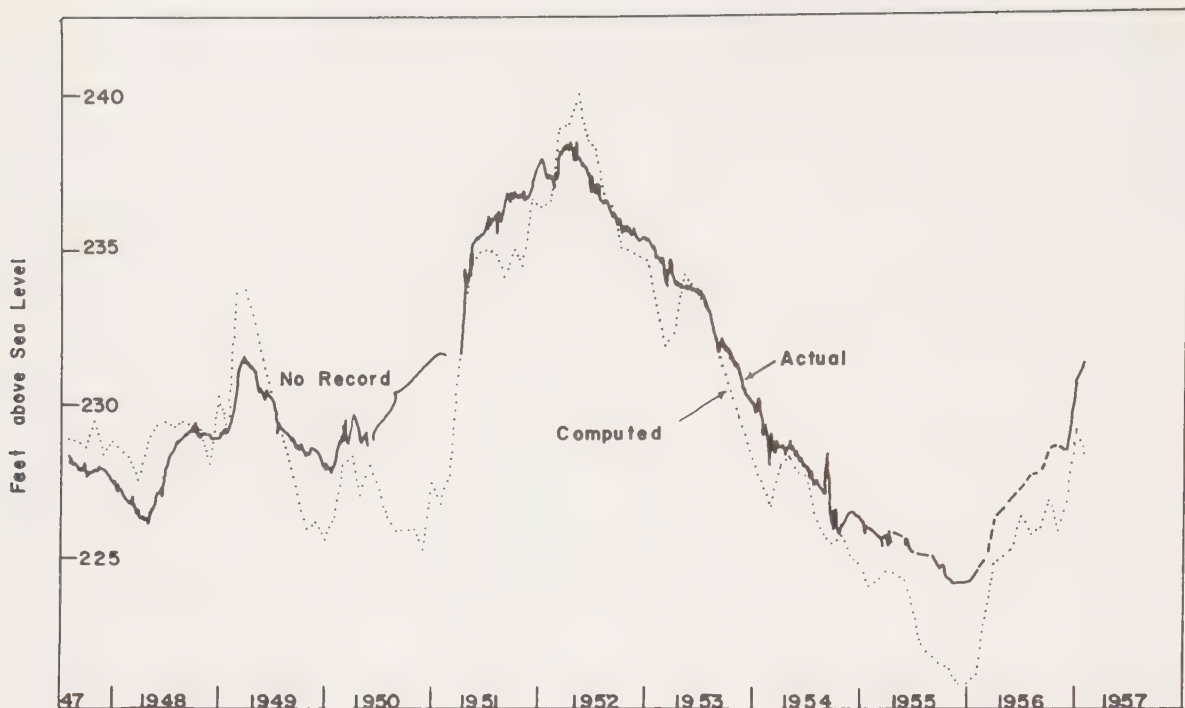


Figure 33. Computed and actual water levels at Pahala Shaft 1947-1957.

PROGRESS IN SPRECKELSVILLE-HERZBERG TRANSITION ZONE STUDIES

Some additional information has been developed on the head and salinity studies on the HC&S Herzberg transition-zone test well at Spreckelsville, Maui. It has been found that the annual variation in water-table level is about one foot, but that this variation is largely a reflection of an annual variation in sea level, amounting to about 0.8 foot. The residual 0.2-foot head change would seem a reasonable index of annual storage changes if the storage changes were computed at 40 times the head changes; in other words, if equilibrium were completely attained in the Herzberg lens from season to season. However, the head variation in the salt water below the Herzberg lens parallels the

variation in the water-table level instead of that of sea level, suggesting a negligible seasonal approach toward equilibrium. It is known that sea level changes, as measured by tide gauges like that in Kahului Harbor, are not accurate indicators of ocean head at depth, because of annual changes in specific volume in the uppermost few hundred feet, and it is possible that the head as measured in the salt water beneath the Herzberg lens is actually a better measure of ocean head than sea level as measured by a tide gauge.

Short-term increases in head following heavy rains are so large as to indicate clearly that equilibrium is not attained in short periods in the Herzberg lens.

RENEWED PAHALA SHAFT WATER LEVEL STUDY

A previous study, relating to the great changes in water level in the Pahala shaft on Hawaii from 1947 through 1951, has been extended to early 1957. The relationship developed earlier, even though crude, still holds, resulting in additional confidence in the method

of analysis used (Figure 33). Methods of forecasting water level changes on the basis of rainfall records, and even on the basis of rainfall estimates from monthly means, have been summarized for the plantation.

KEKAHA MAUI WELLS UNDER CONSTRUCTION

Construction was started by Kekaha last year on two new Maui wells, each intended to be of 15 mgd capacity.

At each, the shafts and sumps are complete and lined, and the wells have been drawn on as the tunnels were driven.

The Saki Mana well tunnel was driven initially with a floor level of -1.0 foot at the sump. It did not penetrate through the talus overlying the bedrock until it had reached 175 feet. After reaching a length of 579 feet, it was deepened to a floor level of -3.0 feet. The

present yield is $7\frac{3}{4}$ mgd with full drawdown. The low specific capacity, only 40 per cent of what was expected on the basis of the median performance of drilled wells in the area, is believed to be within the range expectable by chance, considering the poor sampling of permeability in low-dipping lava flows by a horizontal tunnel. It has been suggested that shallow drilling from the tunnel might increase the yield materially.

The Kaunalewa Tunnel is now 424 feet long and is delivering $4\frac{3}{4}$ mgd.

WATER DEVELOPMENT STUDIES IN WAIHAOLE TUNNEL

The Waiahole Tunnel, which carries water from the windward side of the Koolau Range to the leeward side, passes through 15 dikes of the principal Koolau system, and develops nine million gallons per day in the compartment between them. The original flow from these compartments was very much higher and represented the drainage of water originally above tunnel level.

With the help of the U.S. Geological Survey, an investigation was made of the location, orientation, and character of the dikes, and of the distribution of inflow of water from the various dike compartments, and estimates were made of the permeability and porosity of the rocks between the dikes to permit

analysis of the possible results of developing more water from these compartments.

What appeared to be the most promising method for further water recovery, drilled well development and seasonal pumping, has since been proved uneconomical in the range of pumping lifts studied and with the assumed rate of tunnel recharge to the compartments when they are drawn down. The whole range of conditions under which this sort of development might be performed has not yet been analyzed, nor have other schemes for further dike-water development in the tunnel, but at the moment it appears that further water development would be more economical elsewhere in the dike system.

POSSIBLE WELL DEVELOPMENT OF DIKE WATER IN KOHALA RANGE

In October 1956, a study was made of the part of the dike system of the Kohala Range cut by the east and west branches of Honokane Nui stream in the vicinity of the intake of the Kohala Ditch, to investigate the possibility of obtaining water from the dike compartments in that area by shallow well development and low-lift pumping.

Some of the dikes appear continuous and tight, but those closest above the intake are discontinuous. It is impossible to estimate satisfactorily for any of the compartments the extent to which they are open to recharge from the south, and the extent to which discharge is restricted to the northwest.

Current-meter studies were made by the Geological Survey with the aim of determining losses or gains of Honokane Stream, but the flow was too great to permit precise measurements above the intake, and the flows measured below the intake may represent underflow and seepage from perched springs rather than dike water. However, the prospects for development by the well method appear good on general grounds, and a diamond drill program was recommended by which water levels in the favorable compartments may be determined as a guide to the flow pattern, and permeabilities may be estimated as a guide to well performance.

OAHU BULK SUGAR WAREHOUSE SUBSIDENCE

The floor of the Oahu bulk sugar warehouse, which was completed early in 1955, was found, after the first

year's load of sugar had been discharged, to have settled nearly four inches in places, developing cracks

among the floor slabs and between them and the walls and the tunnel down the center of the building. The logs of holes drilled prior to construction showed the existence of several kinds of material, possibly subject to compression, and one layer of fine lagoon mud that was not only certainly compressible but quite possibly subject to flow.

No previous compressibility or shear tests had been run; so arrangements were made for appropriate tests on samples recovered from new holes just outside the building. The analysis of the test results indicated that the settlement experienced was within the range of, and nearly as great as, that expected from compression

alone. Although flow was not ruled out, it was decided that remedial measures would not be warranted at the time, and a systematic leveling program was initiated by which further changes could be observed.

The second year's experience seems to have justified the decision. Over most of the floor there has been further but slight settlement consistent with an approach toward the limit of compaction. In one area, there has been a rebound of unknown cause but so very slight as to cause no alarm. To eliminate any possible uncertainty as to the future behavior, a re-leveling after the 1957 load has been discharged, has been recommended.

INSECTS

ANOMALA BEETLE AND BEETLE BORER MORE ACTIVE IN 1957

The *Anomala* beetle (*Anomala orientalis*) has now extended its range across the pineapple fields of the Schofield Plateau, which for several years marked its northern limits, into the cane fields of Waialua. The spread is not in itself alarming, as the beetle is not significantly harmful in the usual state of balance with its parasite, but it does bring nearer the danger that *Anomala* may reach other islands of our group. It also creates the prospect of a much more serious problem if a disbalance between the beetle and its parasite should recur, as it did from 1930 to 1934.

Expanding preventive efforts to meet the danger, quarantine regulations formerly applied only to movements of soil and sugar cane from Oahu Sugar and Ewa, were extended early in 1957 to cover Waialua as well.

The situation of *Rhabdoscelus obscurus*, the beetle borer, presents no new development. The beetle is reported unusually abundant on Kauai and Oahu, but this marks only the culmination of a trend which has been in evidence for some years and which is due to the industry's widespread use of soft cane varieties in combination with long-term cropping and, in some cases, insufficient rat control. These conditions simultaneously favor the beetle on the one hand and restrict activities of its parasite on the other, and must in the end result in abundance of the beetle at all times. The situation is unsatisfactory, and unlikely to improve materially without a return to harder varieties and short cropping. Fortunately, thanks to the ubiquitous activity of the tachinid parasite, *Microceromasia sphenophori*, the situation is not apt to deteriorate further.

ARMYWORMS AND CUTWORMS STUDIED

Armyworms were again unreported this year from any cane field. On the other hand, the greasy cutworm, *Agrotis ypsilon*, which appeared in large numbers for the first time in history during 1956, has continued to infest young cane on Kauai throughout most of 1957 (Figure 34). The populations have been much thinner than they were last year and their damage was mostly unnoticed, but they do mark a new status for the pest, which in the early years of the industry was found only as a minor component in mixed populations of other cutworms and armyworms, usually in the spring.

Since the changed status of *Agrotis* is very probably due to a differential effect exercised upon it and its parasites by today's methods of weed control, it is encouraging to note that *Apanteles marginiventris*, one of the principal parasites of the armyworm-cutworm

complex, is still an effective factor in the situation and that wherever *Agrotis* has shown up, this little wasp has immediately followed and soon put an end to the trouble.

Spodoptera mauritia, scourge of lawns and newest member of the armyworm complex, has continued its depredations on the lawns of Honolulu more or less unabated, and early in the year was found in many lawns on the island of Kauai. In spite of the extension of its range, however, *Spodoptera* has not been found on sugar cane, and it has become evident that the species cannot cope with the conditions it finds in our cane fields, which is not the case with cane fields in Australia and other countries. The reasons for this inability will be elucidated in a two-year study of the insect's biology which has just been completed in the Entomology Department, and will soon be in print.

NEW IMMIGRANT INSECTS APPEAR

Among a dozen or so insects which entered the Territory or were found here during the year, only one deserves mention in connection with the sugar

industry. This is a large beetle, *Calendra cariosa* (Olivier), a relative of our beetle borer but of eastern American origin and known in the South only as an

occasional denizen in the roots and lower portions of sugar cane, more often preferring corn, sedges and other plants (Figure 35). The first adult was found on a beach near Kahuku in July 1956, but since then two more have turned up, one in a Waipahu cane field and the other on the roots of a sedge in Wahiawa, a considerable distance from cane. Obviously the species has become securely established, but the insect seems to be of low potential and will probably not attain importance as a pest of sugar cane or any other commercial crop.

Calendra does not belong to a group of insects strongly attracted to light and was not detected origi-

nally by means of a light trap; but in the constant effort to prevent establishment of other, possibly much worse, pests, the Entomology Department has continued to run light traps at Waipio and Ewa, and early in the year installed one more trap in a mauka field of Oahu Sugar. In addition, two more light traps are being run intermittently at Aina Haina, Honolulu, in connection with studies on the biology of the lawn armyworm; and these, too, should help in the detection of new immigrants. They have already done so, in the case of a more or less innocuous moth which had escaped detection nearer the airport, presumably the point of entry.

THE INSECT IMPACT ON CANE GROWTH RETARDATION

In cooperation with the Pathology Department, renewed attention has been given to the recurrent problem of growth retardation of young cane on the Hilo and Hamakua coasts. To determine and evaluate the factors involved, a series of field tests was installed on five plantations and visited with the pathologists at monthly intervals during the first half of the year. From these tests it appears that the role of insects, when they are a factor in the problem at all, is second-

ary and dependent for importance on the condition of seed and root systems as determined by cultural practices and ecological conditions in the problem areas.

This contention, long based by entomologists on more or less casual observations, is being tested further in another series of experiments only partially installed which will juxtapose the factors of the first series in areas freed of insects and other organisms by fumigation of the soil.

MEALYBUGS GIVEN CLOSE SCRUTINY

Studies on the bionomics of sugarcane mealybugs were discontinued at the end of 1956, the work of that year having confirmed previous findings. Only one experiment was carried on into 1957, and this was terminated in January.

This was a pot experiment, installed in December 1955, to determine any measurable weight difference between cane grown in mealybug-infested and in mealybug-free conditions. It comprised 24 pots, six for each of the varieties 38-2915, 37-1933, 32-8560 and H 109. Half the pots were sprayed at weekly intervals with a 0.25 per cent emulsion of malathion to prevent development of mealybug populations, while in the course of the experiment, the remaining three pots of each variety were seeded three times with gravid females of the pink mealybug, *Saccharicoccus sacchari*. Effectiveness of the spray and development of mealybug populations were assessed three times during growth of the cane by counting all the mealybugs on one primary stalk from each pot. The canes were harvested at 13 months of age, and the yield of each pot

was determined in terms of millable cane.

In the course of the experiment it was found that although malathion did not completely eliminate mealybugs, it did maintain the populations of the bug at a minimum. Unfortunately, analytical comparison of the weights of millable cane from the sprayed and the unsprayed pots did not show a significant difference. The question remains, therefore, whether even very small numbers of mealybugs might have some deleterious effect upon the cane plant.

As this question has direct and important bearing on the broader problem of varietal decline in sugar cane and is of interest per se, search has continued for another insecticide which, unlike malathion, shall be able to eliminate mealybugs completely. After disappointing trials with sodium selenate, schradan, and demetron, another systemic insecticide provisionally distributed as Shell-OS-1836 (2-chlorovinyl-diethyl-phosphate) has recently given promising results in limited tests and is to be investigated further on a larger scale.



Figure 34. *Agrotis ypsilon* (Roth.) moth and larva. The black, or greasy cutworm, formerly found in the cane fields only as a minor component of mixed populations of armyworms and cutworms, now is often found on Kauai in pure and fairly extensive populations which do some harm to young cane. (Wing span 1¾".)



Figure 35. *Calendra cariosa* (Olivier), a recent immigrant from southeastern United States, is related to our beetle borer, and is capable of reproducing in the roots and lower stem portions of sedges, corn and sugar cane. (¾" long.)

A CONCENTRATED ATTACK ON RAT CONTROL

Rat studies, transferred to the Department of Entomology at the first of the year, have been pursued along three principal lines: first, development of much needed basic information on the comparative biology, ecology and distribution of the four species of rats found in the Territory; second, further testing of the adaptability to airplane application of generally used baits, such as extruded pellets and double torpedoes; and third, development of new baits adapted to airplane application.

Biological and ecological studies have been made by means of direct observation and through population samples obtained by trapping. More than 12,000 traps have been laid during the year in connection with various surveys, tests and experiments, and the catch has been carefully recorded as to species, sex, weight, age, and any unusual feature of the particular specimen or its capture. Although this is only a beginning, these studies have already turned up several items of new or hitherto unverified knowledge which bear directly and importantly on the economics of rat control. Most important of these items has been the knowledge, supported for the first time by clear evidence, that the rat of predominant abundance and importance in the cane fields of Kauai during severe infestations is the Norway rat, that this species is distributed sporadically in groups which exclude other species, and that the species is only of incidental occurrence in the deep-forested gulches which dissect the plantations.

This knowledge narrows the rat problem considerably and points to the fallacy of the suggestion that the entire area of any plantation must be treated periodically to solve the problem. It is now clearly indicated that the deep gulches of Kauai may be neglected, and that treatment of the cane fields themselves and of the grassy fields next to them should suffice.

A beginning towards a detailed study of rat conditions on the island of Hawaii, comparable with that made on Kauai, was made in July, when partial surveys of five plantations (Hawaiian Agricultural Company, Hutchinson Sugar Company, Ltd., Hilo Sugar Company, Ltd., Onomea, and Kohala Sugar Company) and the Keau Macadamia Orchard were conducted by means of 18 trap lines laid at elevations ranging from 600 to 2,800 feet above sea level. The information obtained is not definitive and must be supplemented

and verified, but it already points to three important conclusions:

First, rats, including the Norway rat, are more abundant in cane fields of the Big Island than is generally conceded, this abundance being often of the same order of magnitude as that ordinarily prevalent on Kauai.

Second, the ratio of abundance of the four species of rats in the cane fields of Hawaii is more apt to vary from place to place than on Kauai, but the Norway rat is often the predominant species in cane fields on the Big Island, although less consistently so than on Kauai.

Third, the mongoose has not eliminated the Norway rat as an important pest of sugar cane on Hawaii, as is often assumed. It can be found in many fields with the Norway rat and has not altered the usual pattern of this rat's distribution in more or less discrete foci of population.

To determine the efficiency of thallous sulphate pellets and torpedoes applied by aircraft, two experiments were conducted at Lihue during November 1956 and January 1957, respectively (Figure 36). Both experiments included extensive areas of cane and gulch or fallow land with thick rat populations, and both were checked by means of pre- and post-application trapping on a large scale.

In the first experiment, about 40 acres of large cane and 50 acres of forested gulch were treated with pellets (Doty formula #6) at the rate of 26.3 pounds per acre, and it was found that the pellets killed about three-quarters of the black (*R. rattus*) and the Alexander rats, but less than one-tenth of the Norways. Since most of the Alexanders and blacks were in the fallow areas, and most of the Norways in the cane itself or its immediate surroundings, the differential could not be accepted, and pellets of the formula used in this experiment were excluded from further trial on Kauai.

It was then decided to try torpedoes on the surviving rats, and two weeks later 785 pounds of Lihue thallous sulphate double torpedoes were broadcast by plane over the same 90 acres. The mechanics of application presented little difficulty and the torpedoes were well distributed over the area at the rate of 7.6 pounds, or 450 to 500 torpedoes, per acre. The results, however, were again disappointing, as the post-

Figure 36. Field 41, Lihue Plantation Co., Kauai. The rectangle outlined in black covers about 103 acres and shows the cane and gulch areas included in one of the experimental applications of pellets and torpedoes by aircraft.



application trapping showed a slight shift in the ratio of abundance of the four species of rats, but no overall decrease in their total number.

In explaining this failure, it was assumed that it was not a fault of the torpedoes themselves, but was due to bait shyness induced in the rats by the previous application of pellets containing the same poison. It was then decided to give the torpedoes a second trial, eliminating the probable weakness of the first.

The second trial was made on Field 38B Hanamaulu at Lihue in January and February. Torpedoes were applied at a rate of 7.9 pounds, or approximately 500 torpedoes per acre, over 47.83 acres of big cane and 22.43 acres of gulch land. Smaller areas of big cane and gulch (24.17 acres and 15.92 acres, respectively) were left as untreated controls. The whole area was carefully checked with 750 traps, once just before treatment and twice after treatment, with an interval of about a week between the two post-treatment trappings. The unusual second post-application index was considered necessary as a check on the first, which might have been influenced by heavy rains (9.05 inches) which fell on the island immediately after the torpedoes were broadcast.

The results of the three trappings are confusing in that they show an unexpected and unexplained reduction of the total rat population in the control, as well as in the treatment, areas. The reduction, however, was significantly greater for all species in the treated area, and significantly less for the Norway rat than for either the black or the Alexander rat in both the control and test areas. It has been concluded,

therefore, that torpedoes of the type used are more effective against black and Alexander rats than against Norways in cane fields, but that their over-all efficiency is considerable and makes them a useful tool in connection with aircraft application.

Lihue, which originated the double torpedoes and had used them extensively in spot application by hand previous to the experiment, has more recently applied them by aircraft on field scale in the course of control operations. Their limitations in this respect are their differential effect upon the Norway rat and their relatively high cost, which is increased by the number of torpedoes which break upon impact with the ground (four to five per cent) and the number which lodge in the axils of sugar cane or bushes and are wasted.

In the search for new and more efficient baits to apply by aircraft, new carriers as well as new poisons have been considered. Limited laboratory and field tests have been made with a number of commercially prepared pet foods in pellet form, and with two poisons, tetraethyl pyrophosphate (TEPP) and sodium phluoroacetate (1080), not hitherto employed in cane fields. All of these materials appear to have potentials worth further exploration. The most promising combination found to date, however, is that of corn (maize) kernels as the carrier and the well-tried thallous sulphate (Ti_2SO_4) as the poison.

In cooperation with the Chemistry Department, it has been found possible to impregnate corn with enough thallous sulphate to kill rats with one to four kernels by simply soaking the grain, or boiling it, in

a solution of the poison; and field and laboratory tests have shown that corn, so impregnated and treated with 1/10 per cent sodium benzoate, is at least as well accepted by rats as the rolled oats, and is almost completely resistant to molds in the field or in storage.

Actual broadcasting of corn bait by aircraft has not been tried in the Territory, but reports from the Philippine Islands indicate that it should be easier and more efficient than broadcasting of bulky, relatively soft torpedoes, and no more difficult than broadcasting of seed or granulated fertilizers. It should also be much cheaper than pellets at 40 cents a pound or torpedoes at approximately \$1.00 a pound, for raw maize costs about five cents a pound in Honolulu and should eventually come to about 25 cents a pound in the field, fully prepared for application.

The rat-killing efficiency of corn bait was tried with encouraging results on a field scale at Lihue in May, the last time that a suitable area for such a trial was available. In this test the prebait principle was combined with broadcasting of the bait over the ground, but there are indications that in certain conditions corn may prove efficient as a one-shot bait.

In the Lihue experiment, the bait was prepared in Honolulu and shipped to Lihue, still moist, in large waterproof plastic bags contained in cardboard drums. The drums were loaded on a small delivery truck and the grain thrown out by hand as the truck moved slowly along the area of the experiment, which was a strip of brush 16,000 feet long, on the edge of a newly-harvested cane field. The width of the strip was determined by the distance a handful of corn could be thrown, and varied from 10 to 20 feet. In a first prebait application, 320 pounds of water-soaked, unpoisoned corn were broadcast over the entire length of the 16,000-foot strip. In a second prebait application, seven days after the first, the procedure was repeated. In the poison-bait application, four days after the second prebait, 380 pounds of corn were

used to treat the first and third quarters of the strip only, permitting the other two quarters to serve as control areas.

The whole length of the experiment was trapped with 376 numbered traps just before prebaiting, on May 2 and 3, and again on May 21 and 22, 10 days after poisoning. The results are shown in Table 5, in which the figures are the population indices (rats caught per hundred trap days) in each sector of the experimental area.

As the table shows, the results were not clear-cut at the time of the first post-poison trapping. The index had fallen significantly in one poison area (from 8.0 to 2.7 rats per hundred trap days) but not significantly in the other (from 6.4 to 5.3), and the index of one of the controls had very materially risen.

These figures pointed to the possibility that the poison had not affected the rat population, and that the small reduction in one poisoned sector and the relatively large reduction in the other might have been due merely to migration of rats from the poisoned sectors to the control sector between them.

It was not possible to explain why this should have happened, if indeed it had happened; but the situation was not felt to be normal nor to reflect truly the new bait's usefulness. It was then decided to try the bait again, in one of the sectors used as a control in the first trial.

On May 23, poisoned corn was scattered on this sector (Control 283-376) with the same technique used previously; and seven days later the sector was trapped again. The index, as the table shows, had fallen this time from a prepoison high of 14.4 to an extremely low 0.5 rats per hundred trap days. This figure, it is felt, is in accord with the potentialities of corn as demonstrated in previous laboratory and field tests. The range of field conditions under which duplication of it can be reasonably expected remains to be determined.

TABLE 5
Indices (rats 100 trap days) Obtained During Test of Thallous Sulphate-treated
Corn Broadcast in Brush Along Field #30 Hn., Lihue Plantation

Dates Trapped	Trap-station Numbers			
	Test 1-94	Control 95-188	Test 189-282	Control 283-376
May 2-3; pre-poison.....	6.4	5.9	8.0	14.9
May 21-22; post-poison.....	5.3	11.2	2.7	14.4
May 29-30; post-poison.....	.....	.....	.....	0.5*

* Stations 283-376, previously used as a control group, were poisoned on May 23 with the same technique employed on the original test areas.

IRRIGATION

FIELD MOISTURE CONSUMPTION BY SUGAR CANE

A field study of moisture consumption was initiated in the spring of 1957 by the Departments of Agronomy and Geophysics in cooperation with HC & S. An immediate objective of this project is to determine a peak field moisture use rate suitable for overhead irrigation design purposes. A second and more complex objective is to relate moisture consumption to climatic factors to permit extrapolation of peak and mean use rates to other areas, and, if possible, to permit adjustment of irrigation intervals.

Moisture consumption is being determined at approximately weekly intervals, in a total of nine lysimeters, 1/1000 acre in area and four feet deep. These lysimeters were divided into groups of three and installed in widely different climates at HC & S. The lysimeters are five feet wide and 8.71 feet long, and the cane is planted in a shallow furrow located in the middle of each tank and running the length of the tank. The lysimeter tanks are located a minimum of 50 feet inward from the nearest boundary of furrow-irrigated cane of the same age as that in the lysimeter. Each field with lysimeters and weather instruments is surrounded by other fields of cane of various ages.

Standard weather instruments are used at each installation for measuring rainfall, temperature, humidity, wind, sunlight and evaporation. The instruments are installed on platforms whose height is adjusted

to the height of the surrounding cane. The evaporation pans rest directly on the platforms, and the temperature, humidity, and wind instruments are installed at one and two meter heights above the platforms. A net radiometer is installed in addition to the standard instruments in Field 906 in the Maalaea area.

Lysimeter moisture consumption in Field 906, together with standard weather bureau pan evaporation, is plotted in Figure 37. The ratio between mean evapotranspiration and pan evaporation is shown in Figure 38. The pan evaporation since May has averaged 0.29 inches per day, tending to be somewhat higher in May and June than in July and August. Lysimeter consumption for a period of 45 days beginning June 29 averaged 0.28 inches per day. Peak moisture consumption was recorded for a week at the end of July when the average water use reached 0.38 inches per day. A comparison of the total water consumed by cane in each of the three lysimeters is nearly identical.

The close agreement between the over-all averages of lysimeter consumption and pan evaporation is coincidental. The ratio of lysimeter consumption to pan evaporation has shown a consistent increase from a value of about 0.4 in late May to about 1.1 in early August. This increase is related to the growth of the cane and the completeness of ground cover.

SOIL INFILTRATION STUDIES IN RELATION TO IRRIGATION

The sprinkler infiltrometer briefly described in last year's report has been in operation during 1957. The primary objective of this work has been to develop an understanding of the influence of surface slope, slope of land, and surface cover, on the infiltration properties of various soils, and to attempt to fit these concepts into a single-valued infiltration term suitable for overhead irrigation design purposes. Because the experiment is rather comprehensive, only a few typical

results are shown to indicate magnitude of differences for various treatments in Table 6.

Trash cover applied to the soil at the rate of five tons per acre absorbed 0.68 inches more water during a 1.5-hour water application period than the corresponding bare surfaces in different grades. The effect of slope on water intake is shown in Table 6 for a flat bare surface.

The results show that a 10 per cent slope increase

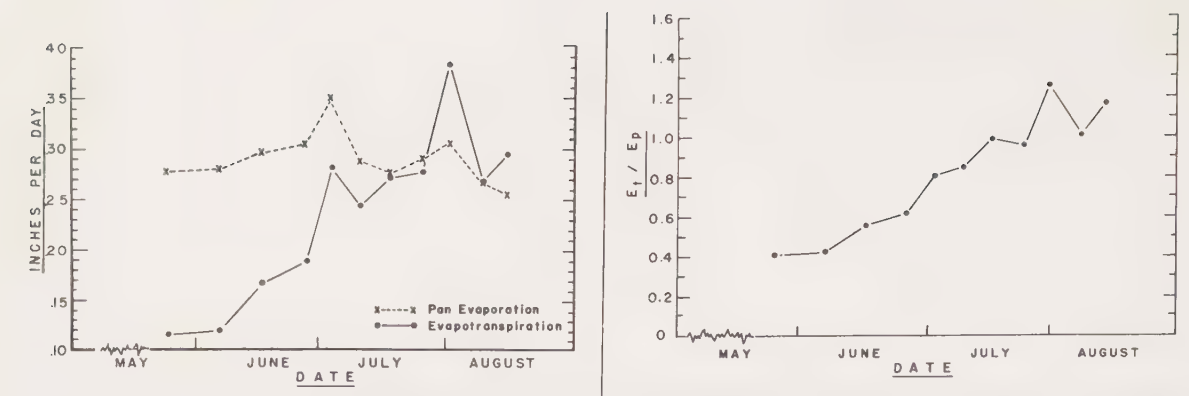


Figure 37. (Left) Evapotranspiration of cane (inches per day) plotted against time of year. The crop was two months old on May 23, 1957. Standard weather bureau pan evaporation inches per day is related to time of year (1957). Figure 38. (Right) The ratio of evapotranspiration to weather bureau pan evaporation (ET/EP) is shown for the summer months of 1957.

gave a 22.2 per cent decrease in water intake. The flat bare surface on the 0.0 grade absorbed 0.18 inches more water than the furrowed bare plots on the same grade during the 1.5-hour application period. If the

various factors that influence intake rates are listed in order of magnitude of effect, i.e., to keep water intake high, they would be (1) surface cover, (2) surface shape, and (3) slope of field.

TABLE 6
Effect of Surface Cover, Slope and Shape for Pulehu Silty Clay Loam on Infiltration Rate

Treatment	Application Rate (Inches/Hour)	Water Absorbed During 1.5 Hrs. (Inches)
<i>Flat Surface (trash cover)</i>		
Slope 0.0.....	1.49	1.95
3.0.....	1.52	1.86
10.0.....	1.50	1.79
Average.....	1.50	1.87
<i>Flat Surface (bare)</i>		
Slope 0.0.....	1.53	1.35
3.0.....	1.50	1.18
10.0.....	1.49	1.05
Average.....	1.51	1.19
<i>Furrowed Surface (bare)</i>		
Slope 0.0.....	1.49	1.17
0.5.....	1.51	1.13
1.5.....	1.51	1.08
Average.....	1.50	1.13

SOIL SURFACES STUDIED AT HC&S

A ridge-type layout, developed from infiltrometer studies, is being tested in one-acre plots at HC&S. These plots are being compared with two standard deep irrigated furrow layout plots and two shallow

furrow plots. The shallow furrows are about eight inches deep. All plots are irrigated by overhead equipment. The ridge is about eight inches high on contour and on the slope downfield from planting.

The ridge is easily formed, easy to repair and provides greater opportunity for water to infiltrate than either a uniformly flat or deeply furrowed surface. The ridge layout provides a surface more suitable for mechanical

harvesting operations than furrowed surfaces. Larger scale field testing over a wide range of field slopes is needed, as well as an evaluation of the ridge layout in terms of other cultural practices.

IRRIGATION WATER FLOW STUDIED IN CANE FURROWS

During the past year, water-flow studies have been used on several plantations to determine irrigation time. The field test procedure conveniently separates into two steps: (1) a determination of the time required for the soil to infiltrate an adequate amount of water in that section of the furrow most likely to be poorly irrigated; and (2) a determination of the time required for water to advance to the critical section of the furrow, namely, the end section which is the most difficult to irrigate.

The same data, if sufficiently complete, are suitable for adjusting length and slope of layouts. These studies should remain a basic part of furrow irrigation re-

search because the furrow is the smallest and most fundamental unit in an irrigation system.

A project was initiated at the Waipio Substation to compare the water flow in a standard planting in the bottom of the irrigation furrow with that in an offset planting in a broad furrow. Flow measurements will be made periodically as the crop increases with age to evaluate the resistance to water flow in the two types of plantings.

This type of planting has been used for many years at Paauphau Sugar Company, Ltd. in order to obtain a better distribution of water in their highly permeable soils.

USE OF GYPSUM BLOCKS EXPANDS

A smaller helical-coil-electrode block has been adopted as standard and several thousand have been produced for irrigation control this year. The new shape of the electrode and dimension of block give a more stable unit and cut manufacturing time in

half. The base readings of the new blocks when wet remain lower than the old type and are easily read by the Bouyoucos "Moisture Meter" or the Fisher laboratories "Moist Meter" which are gradually replacing the model C Bridge for field use.

PRI-WAIPIO LYSIMETER STUDIES 1956-1957

The cooperative PRI-Waipio lysimeter experiment has been continued at the Pineapple Research Institute's Waipio Field Station. The sod in the Bermuda grass lysimeter deteriorated during the winter and the cover dropped four to six inches below the lysimeter rim as a result of soil slumpage. The lysimeter was refilled with soil, the sod fertilized, and the sod re-established during June 1957. The moisture consumption of the revitalized sod has been approximately equal to the rate of pan evaporation. This is in de-

cided contrast to the consumption of the depressed cover which had been only one-half the rate of pan evaporation.

The pineapple cover was removed in June and the lysimeter filled within two inches of the rim. Moisture consumption of the fallow soil under weekly irrigation has been about half the rate of pan evaporation. Pineapple cover will be restored to this and the third lysimeter in October to maintain the area in cycle with block A-1, immediately upwind.

MECHANIZATION

PICKUP-TRANSPORT FOR V-CUT CANE

The self-loading infield transport described in the 1956 report has been in operation on an experimental, development, and semi-production basis. The quality of pickup with good V-cutter cut-windrowed cane has been satisfactory. With wet as well as dry conditions, the field can be left in ratoenable condition (Figure 39).

A machine such as this, equipped with a conveyor which handles cane, is in a class which requires planned maintenance, as well as good operation and fields with few rocks. Long range production will be directly related to these factors.

An experimental phase of the design was the use of aluminum alloys for the construction of the body and loading conveyors. 9400 pounds of structural steel and plate were replaced by 4600 pounds of aluminum alloy, a weight saving of 4800 pounds. The aluminum construction has been generally satisfactory except for the cost in time required for field repairs, which is high when compared to repairs on steel construction. Until aluminum construction can be repaired in a manner similar to steel, its use on field machines will continue to be limited.

TWO-WAY CUT-LOAD MACHINE MAKES TRIAL RUNS

The two-way cut-load machine has been operated on a test and development basis at Olokele Sugar Company, Ltd., from November 5 to 15, 1956, and at Grove Farm Company, Ltd., from February 25 to May 10, 1957. A total of about 35 acres was cut during these periods (Figure 40).

After some machine improvement and development, two initial objectives were set up, (1) to attain minimum tare delivered to the transport, and (2) to leave negligible liliko on the field. Attaining satisfactory production is considered a second phase and is a longer range problem since production is tied in with the irrigation system and field layout.

Changes which have been made in order to reduce

The performance is described by the following data: (1) average load, seven gross tons; (2) loading time, four gross tons per minute; (3) production, 30 to 75 gross tons per hour on total time basis, depending on conditions and length of haul.

General specifications:

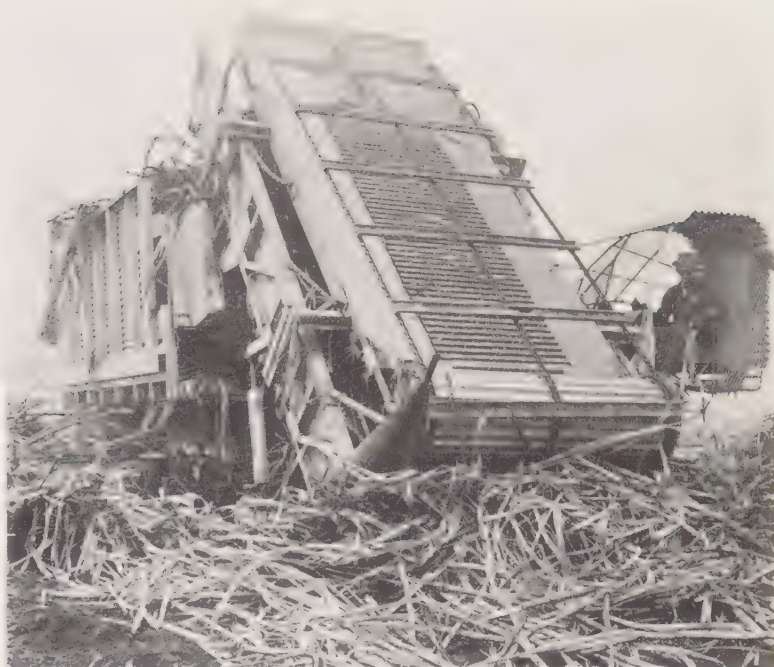
Over-all length	26½ feet
Over-all width	16 feet
Weight (unloaded).....	22 tons
Average ground pressure with 7-ton load.....	5.5 p.s.i.
Gauge	9 feet
Power	125 hp
Travel speeds.....	1.1 to 4.2 mph
Prime mover drive.....	torque converter
Loading conveyor drives.....	oil motors
Unloading conveyor drives.....	mechanical
Controls	air actuated

In computing the cost of producing a new machine, the cost of the original machine cannot be considered conclusive. However, indications are that the cost per ton compares favorably with the cost per ton of the present system of push-raking V-cut cane into larger windrows and grab-loading into a standard cane buggy for the infield transport.

tare are: (1) installation of a detrash-load conveyor which has a peg-tooth drum blower assembly designed into it; (2) changes to cross-flow cutters and conveyor headshafts to increase completeness of cutting; and (3) increase number of gaps in the elevating conveyor decks.

Changes which have been made to reduce liliko are: (1) improved gauging of cutting height and furrow-follow by use of 16x15x6 Rolligons for gauge wheels, plus improved counterbalance linkage; (2) better sweep of furrow cross section; (3) relocation of side-trim knife; (4) better synchronization of pickup and travel speeds; and (5) longer elevating conveyors to reduce the slope from 35 to 30 degrees.

Figure 39. Pickup transport in operation at Pepeekeo Sugar Company, showing improved divider.



The hydraulic circuits have been simplified and a number of hoses eliminated by the use of remote control valves. One valve now serves where before it was necessary to have a valve on each operator plat-

form for each circuit, plus a cross-over valve between circuits. Also, since the remote control valves are located near the motors, the hoses are reduced in length.



Figure 40. Two-way cut-load machine in operation at Kahuku Plantation Co.

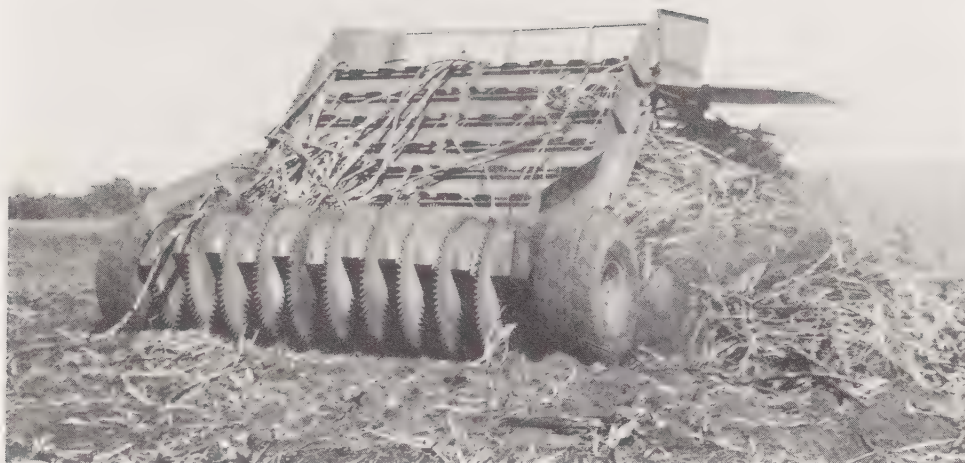


Figure 41. Liliko pickup, discharging accumulated load of cane.

SEED CANE HARVESTER READY SOON

A machine for cutting one row of erect seed cane has been designed and is being constructed. Its principle is to cut the cane off at the ground after the stalks have been engaged by the gathering chains and topped. The cane tops will be dropped onto the ground. The stalks will be conveyed continuously in the erect position through three high-speed, small-tooth saws which will cut them into seedpiece lengths. The cut cane and leaf trash will be conveyed across the prime mover and directed into a bulk seed bin by a deflector plate. This action, plus an air stream from a blower, should accomplish effective detrashing.

This project ties in with Kohala's plan to produce all of their seed in a centrally-located area. This ex-

ploration of the practicability of a complete system for producing, cutting, treating and handling seed marks the first instance where the layout and culture of an area has been planned to facilitate the use of a machine.

General specifications:

Over-all length	16'-8"
Over-all width	17'-8"
Est. weight (including prime mover)	15 tons
Prime mover	TD14, D6 size standard tractor, 60" gauge
Engine power	75 hp
Travel speeds	1.4, 2.3, 3.2, 4.4, and 5.8 mph
Cutting speed	1.4 mph (123 fpm)
Drives	Mechanical and oil motors
Estimated production	at 123 fpm tractor speed, 5.2 tons per hour based on estimated 60% availability

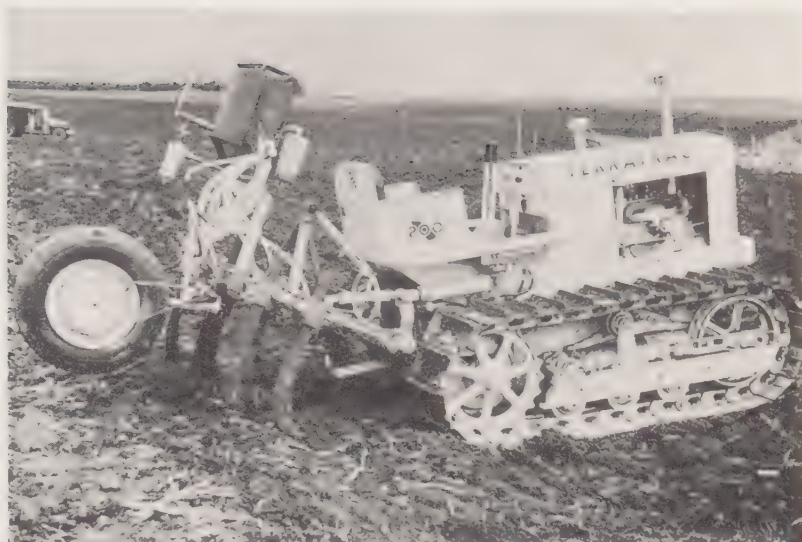
LILIKO REDUCTION AND PICKUP ATTACKED

The objectives of the liliko reduction and pickup projects have been (1) to mechanize the liliko operation regardless of the type of harvesting, and (2) to reduce the amount of liliko left in the field by harvest machines, particularly cutters (Figure 41). The amount of liliko left by any harvest machine is a direct measure of the quality of its work. To attain the objectives, the work has been divided into four phases:

1. Design and development of a liliko pickup and of a liliko cutter-windrower.
2. Adaptation of harvesters to reduce liliko.
3. Suggestions for changes in cultural practices.
4. Improvements in operator skill and machine adjustment.

A liliko pickup machine, 10 feet wide, has been completed and is being field tested and developed. The pickup is done by 10 star wheels 42 inches in

Figure 42. Power rig for applying soil fumigants. The ground-driven pump assures uniform application.



diameter, which are spaced 12 inches apart and are independently oscillated. The cane pieces are speared by or wedged between the V-shaped teeth, and are stripped off at the top by deflector plates. The pieces are elevated by a conveyor into a bin which can be unloaded from either end. The unit is a semi-trailer-type and is used with a TD9 or D4 tractor.

The liliko cutter-windrower is being designed to cope with the problems peculiar to grab-harvesting. Most of the liliko is attached to stools and ranges in length from one to five feet. The preliminary design consists of gathering-tines, a small rotary ground knife, and sticker chains for elevating the pieces to a bin which can be unloaded by conveyor bottom. The prime mover is a small track-type tractor.

Design changes in cane cutters and additional mechanisms for the reduction of liliko can be field tested on a cut-pickup-elevating conveyor for a side-mounted

machine. Ideas on the drafting board include: (1) additional pickup tines; (2) substitution of 60x42 Rolligon for 18:00x24 tire for outboard wheel; (3) addition of a free-cutting side knife; (4) installation of a conveyor-chain-driven ground knife which would allow a full-length center conveyor chain; (5) a means to shunt cane lost through desoil gaps into standing cane; and (6) addition of a drum-type pickup reel.

All mechanization of field operations encounters problems due to cultural practices, most of them having to do with furrow irrigation. It is hoped that modifications of field layouts, curvature of lines, furrow cross-sections, line spacing, hapas, and location of stools can be adapted to the conditions of mechanization, without sacrifice in other areas.

It has not been possible, with any agricultural field machine, to divorce operator skill and proper machine adjustment from quality work.

METAL FLUME PICKUP

The metal flume pickup, a lightweight, track-type unit, has proved to be a convenient means of transporting and distributing metal flumes and attachments in the field. Based on field experience with the experimental unit, the drawings of the prime mover with

storage racks and bins were redone. The results, when this unit was used for flume pickup ahead of harvest, were good. However, the nose assembly which lifts and spreads the cane off and away from the flume so that it can be picked up, still needs improvement.

SOIL FUMIGATOR DEVELOPED FOR FIELD EXPERIMENTS

In cooperation with the Pathology Department, soil fumigant injection equipment suitable for installing field tests on plantations was investigated. Three prin-

ciples for metering and injecting such liquids were tested in the laboratory to ensure sufficient accuracy. A commercially available unit which consists of an

eight-outlet, low-pressure gear pump was selected.

A lightweight track-type tractor was set up with this equipment and a tool bar for broadcast application. There were six subsoil shanks with 12-inch spacing. Application depth was 8 to 10 inches.

A later change to one-row application consisted of a furrow plow with an injection shank on each side

of the furrow (Figure 42). Application depth was four to six inches below the bottom of the furrow.

The rates of application have ranged from four to 40 gallons per acre. The major operational problems have been caused by dirt plugging the tube at the end of the shank, and trash accumulating on the shanks and plow.

CUTTER-TRANSPORT DESIGN REVISED

The design and drawings for the cutter-transport were completely revised with several objectives in view; (1) to add nothing which would be classed as experimental; (2) to reduce total weight; and (3) to improve weight distribution. Refinements of design based on field operation of three machines were made. The total weight was reduced by 5000 pounds to approximately 24.5 tons. The weight distribution was adjusted so that, when the machine is on level ground, the weight on each track assembly will be equal.

After the drawings were completed, a plantation request for quotations on parts, materials, and fabrication, revealed that the total cost exceeded the estimated worth of such a machine. Three alternatives were suggested: (1) to increase the production; (2) to design a lighter-duty, lower-cost machine without loss of efficiency; and (3) to obtain substantial discounts in purchase of parts and materials.

The greatest opportunity appears to be in the area of lighter duty design. Design knowhow has progressed to such an extent that there should be no failures of parts or components because of wrapping,

packing-in of soil and trash, interference of parts under adverse conditions, etc. Hazards in the fields, such as large stones, are being reduced. New construction materials which will tolerate considerable flexure are available. It appears feasible that with a further reduction of about 14,000 pounds, a machine weight of approximately 17½ tons would be possible; however, such a machine should be considered experimental.

Some increase in production of a one-way machine may be possible, and a lighter, more maneuverable machine should give some increase. However, it is doubtful if much can be accomplished in this area because of operator fatigue where half the travel is backward.

The possibility of any larger economies through OEM (original equipment manufacturing) discounts was investigated. This discount ranges from 15 to 50 per cent, depending on manufacturer and size of purchase. With limited production of machines, it was found that the possible savings were rather limited, and in some cases, delivery would also be slower.

ORGANIC CHEMISTRY

SUGAR CANE WAX EVALUATION SHOWS POTENTIAL

Preliminary evaluation by several mainland concerns of two-pound samples of crude wax, extracted from the cane cleaner effluent stream, has indicated that the wax has a good potential, but that, in its present form, it should not be considered a satisfactory direct replacement for the more important large volume hard waxes. For polishes, some alteration in the final refining process will be required; the emulsifiability and emulsion stability are poorer than that of present refined cane wax. However, it is believed that a superior wax could be made with less expense and complication than present cane wax from filter muds. At a proper price and volume, it should be

able to find a place in the hard wax classification similar to that of present refined cane waxes. Studies are continuing on possible modification. Refining and alteration would involve the following steps:

1. Removal of soft fatty portion. In wax from the cane cleaners, this may be one to five per cent of the crude wax. In filter mud wax, it is 30 to 60 per cent.
2. Decolorizing to the degree required by end use.
3. Controlled oxidation by oxygen or chromic acid to degree required for paste formulation and emulsions.

Figure 43 indicates the best method developed here for wax refining.

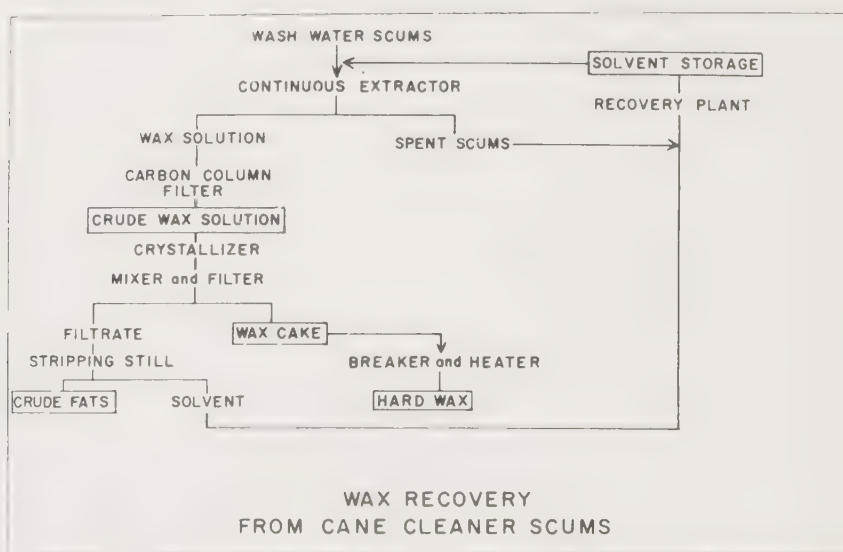
WAX ANALYSES SHOW A MIXTURE OF COMPOUNDS

The crude light-brown hard wax has a slightly burned odor, melting point (m.p.) 80° C., acid no. 6.86, saponification value 15.89, iodine no. 21.1, hydroxyl value 43.0, carbonyl value 24.1. Carbon 81.75, hydrogen 13.89, oxygen 4.36 per cent gives an average empirical composition of $C_{26}H_{54}O$.

Fractionation with boiling acetonitrile or ethanol

gave a soluble yellow wax, m.p. 80° to 81° C., (45 per cent), mainly wax alcohol and some ketone by infrared analysis, and an insoluble brown wax, m.p. 79° to 80° C., (55 per cent), mainly ester. According to the S. C. Johnson Company, saponification analysis indicated three per cent hydrocarbons, 20 per cent wax ketone, 40 per cent wax alcohol and 37 per cent

Figure 43



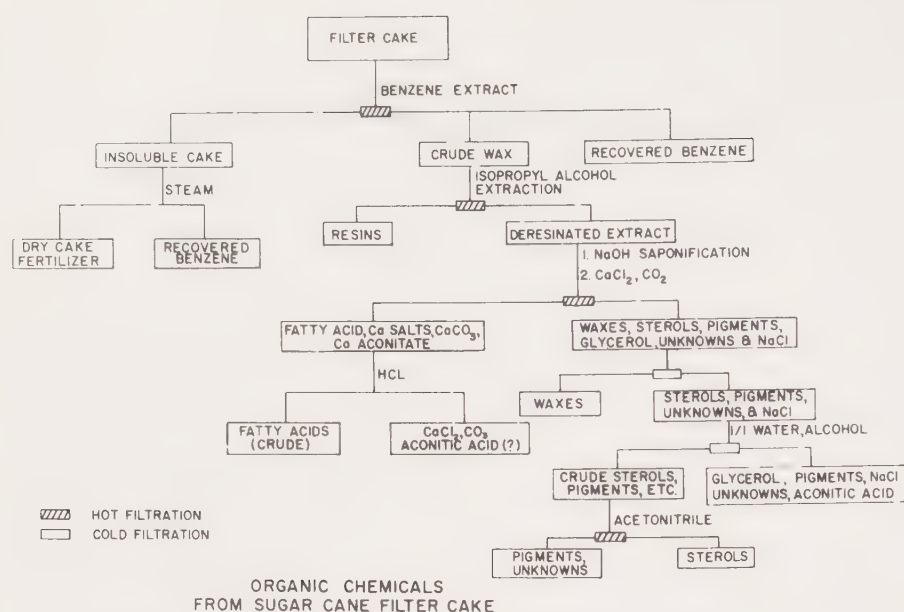


Figure 44

acids. With the low indicated acid number, a considerable portion of the wax acids were esterified in the original wax. Our figures showed a lower acid content of about 25 per cent and a higher alcohol content.

Saponification of the wax with an alkali hydroxide

or alkali metal dissolved in alcohol produced a wax unsaponifiable portion with a light tan color, m.p. 84° C.

The wax acid fraction prepared from the alkaline soaps was a black wax, m.p. 77° to 78° C., 60 per cent recoverable as a pale yellow wax acid, m.p. 84° C.

OXIDATION PRODUCES HIGH QUALITY WAX

An S. C. Johnson and Son Company, Inc. patent indicates a method for improving sugarcane wax for carbon paper use. The improved product results from oxygen gas oxidation of wax to a desired acid number and addition of synthetic resins. Complete oxidation of the cane wax (alcohols) can be easily carried out using potassium dichromate in acetic acid. The white wax, m.p. 86° C., yield 75 to 80 per cent, soluble in

hot acetonitrile, consisted mainly of wax acid by infrared analysis. The green wax residue, m.p. 90° to 92° C., was composed of wax acid salts and a small amount of ester.

A modification of this procedure gave a wax consisting mainly of wax ester in which only part of the wax alcohol was oxidized and esterified with remaining alcohol.

ESTERS FROM WAX ALCOHOLS AS EMULSIFIERS

A water insoluble emulsifier for water in oil has been prepared from the wax alcohol. This material leaves thin, apparently continuous films on the surface

of a container of water as the solvent evaporates, demonstrating potentialities as a means for reducing evaporation from water surfaces.

FILTER CAKE YIELDS WAX, CANE FATS (OR CANE OIL), STEROLS AND FATTY ACIDS

The flow diagram of Figure 44 indicates the preparation of several organic materials from filter cake extracts. Such a procedure would be necessary as a preliminary fractionation of so complex a mixture.

Samples of the crude dewaxed filter cake extract were analyzed by the Research Laboratories of General Mills, Inc., as a source of sterols. Their results show the crude oil contained:

Unsaponifiables (wax unsaponifiable, sterol, glycerol)	13.6%
Acids (by difference) (fatty, wax, aconitic, etc.)	86.4
Sterol	6.1
Stigmasterol	21-22%
beta-Sitosterol	78-79%

Present demands for stigmasterol for use as an intermediate in preparing cortisone are currently being met with soybean oil residues.

The market for sitosterol for the treatment of atherosclerosis is very uncertain at the present time. Sitosterol administered in fairly large doses apparently lowers blood cholesterol levels. The principal source of sitosterol is from tall oil residues from paper-pulping liquors, and the supply is potentially unlimited. On the other hand, there is evidence that vegetable oils

rich in unsaturated acids, particularly linoleic, can be used for the same purpose. Armour and Company has introduced such a safflower oil preparation containing vitamin B₆.

Crude cane sterols (m.p. 120° to 121° C.) prepared as in Figure 44, analyze about 52 per cent total sterol by digitonin; the remainder is wax.

Crude sugarcane oil is a greasy, dark red-brown to black material which may be liquid or solid, depending on the wax content. It may be partly decolorized by filtration of solutions through carbon columns or, as done commercially, by saponifying and distilling the fatty acids or their lower esters. Crude sugarcane fatty acids are black greasy pastes considerably darker than most commercial oil acids.

CANE FATTY ACIDS AS A COMPONENT OF SUCROSE DETERGENTS

To prepare the sucrose canate ester, the previously prepared cane oil acid methyl esters were required. The effect of the included waxy fractions was not known *a priori* and was determined by preparation and testing of the surfactant in the HSPA standard herbicide formulations. In summary, it is evident that the cane oil must be free of wax, or else the finished surfactant must be dewaxed before use. Promising herbicide emulsions were made with the sucrose canate when free of wax. Even then the emulsifier was low-

foaming and of only moderate water solubility.

Sucrose stearate surfactant was prepared as an essentially non-foaming soft waxy solid, soluble in aromatic oils and slowly water soluble.

Sucrose coconate, from a sample of coconut oil acid methyl esters, kindly supplied by General Mills, Inc. Research Department, was a soft solid of good foam and water solubility. Sucrose canate occupies an intermediate position in properties between the stearate and coconate esters.

DIALYSIS OF CANE JUICE AND ELECTROPHORESIS OF THE UNDIALYZABLE FRACTION

Cane juice (65° Brix, HC&S, diluted one-fifth volumes with water), was dialyzed in a 2½-inch diameter by four-foot cellulose tube against water. Toluene was placed on top of the juice column to prevent microbial attack. All sugar, soluble salts and other low molecular weight soluble materials were removed within 72 hours. Considerable yellow color was also removed with the solubles. The black liquid remaining was removed after one week and most of the water was removed at 65° C. under vacuum. The

black liquid was filtered through paper, removing a gray solid, mainly bagasse pith. The remaining water was removed in a vacuum desiccator; the yield was about five grams of black brittle solid from 100 grams juice.

Paper electrophoresis of the dried dialyzate, redissolved in water, showed reducing materials not corresponding to glucose and levulose compounds giving ultraviolet fluorescence, and some amino acids and proteins.

AMMONIATION OF BAGASSE PITH

Fundamental study of variables involved in ammoniation of bagasse pith showed that pressure, temperature, moisture content of pith, ratio of ammonia to pith, time of reaction, and rate of heating and cooling, were all important factors in affecting the

percentage of nitrogen attached to the pith. The following general effects were observed:

1. Increase of pressure, temperature, ratio of ammonia to pith, and time of reaction increased the nitrogen content approximately linearly.

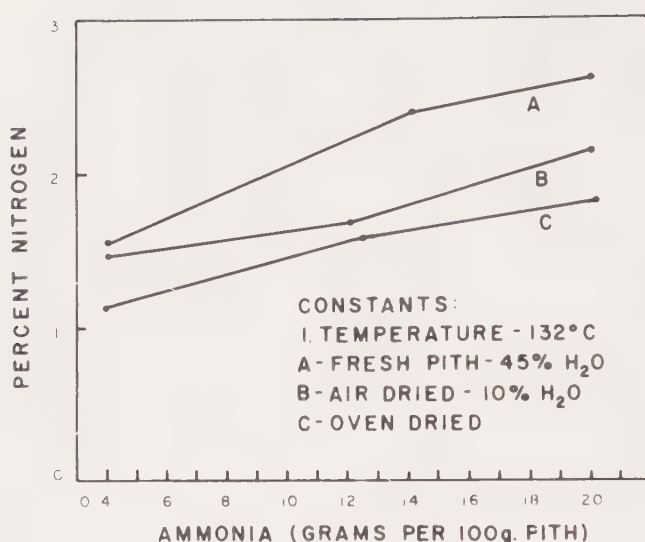


Figure 45. Ammoniation of bagasse pith. Variation of nitrogen with ammonia-to-pith ratio.

2. Ammoniation of fresh mill pith (40 to 50 per cent moisture) introduced more nitrogen into the pith than was the case with air- or oven-dried material (Figure 45).

3. Aqueous ammonia was not as effective as anhydrous ammonia, except at the same total moisture levels. Use of aqueous ammonia would require complete oven-drying of the pith.

4. Rates of heating and cooling are important and emphasize the greater importance of a longer total reaction time.

Prehydrolytic treatment of the pith with a small amount (one to two per cent on dry pith) of acid, preferably sulfuric or phosphoric, and subsequent ammoniation of the product, resulted in a much higher nitrogen introduction than could be accounted for as ammonium sulfate or phosphate. For example, after one hour prehydrolysis at 150° C. (100 p.s.i.), anhydrous ammonia was reacted to 160 p.s.i and 180° C. to give a product of 4.21 per cent nitrogen, air-dried, compared to 2.91 per cent without pretreatment. Only 0.3 per cent nitrogen can be accounted for as diammonium phosphate formed.

A pilot plant for ammoniation of 100 to 200 pound batches (dry weight basis) of bagasse pith was constructed, consisting of a steam-jacketed cylinder mounted horizontally and built to withstand 300 p.s.i. internal, 150 p.s.i. jacket pressures. Operating at two

batches per day, about 400 pounds, dry weight, of ammoniated bagasse were produced per day for about 30 days. Average nitrogen values of 2.2 to 2.5 per cent were obtained. The final volume was about one-third of the original pith; the pith cells were reduced to powder in the process, and water and molasses absorptive ability was low.

A ruminant feed ration, containing 25 per cent ammoniated pith (one-third of the total nitrogen in the mix) with 56 per cent molasses, plus other protein and oil feeds, was prepared at the University of Hawaii and fed to sheep. The animals did not take to the feed readily, although in a few days' time a few animals increased their intake to 900 grams per day against about 1000 grams per normal feeding. Sheep placed in the metabolism cages were never found to consume more than 300 grams per day. Phosphoric acid added to the ration to neutralize any trace of free ammonia or basic nitrogen did not increase the palatability or intake. No toxicity was found in any formulation.

Cattle feeding trials, originally scheduled to begin in July, have been postponed until more preliminary work with sheep has been done. The ration will be fed to growing heifers to test palatability. It would appear on the basis of limited tests, so far conducted, that the feeding value of ammoniated pith is about the same as pith plus urea or pith plus ammonium phosphate.

HARDBOARDS FROM AMMONIATED PITH

Ammoniated pith can be converted by heat and pressure into a dense black hardboard. Testing on a larger scale is being arranged. A uniformly ammoniated product is essential and the moisture content, temperature, pressure, nitrogen content, and pressing time are important. Temperatures of 300° to 375° F., pressures of 1500 to 6000 p.s.i., and nitrogen values over 1.9 per cent are required for acceptable board

formation. Moisture limits are not fully known yet. Reproducibility has been difficult. Density of the product (2000 p.s.i., 300° F.) was about 86 pounds per cubic foot, or 1800 pounds per 1000 square feet of 1/4-inch board.

Water resistance of this type of board was not particularly outstanding, unless a small amount of resin was added.

INTERESTING COREBOARDS FROM BAGASSE AND BAGASSE PITH

Treatment of dry bagasse and bagasse pith with new organic binders has been extended to low pressure board formation conditions suitable for commercial equipment. Five per cent by weight of the binder mixed with dried bagasse pith and pressed at 400° F. and 500 p.s.i. for three to six minutes resulted in a block of about 33 pounds per cubic foot density, of excellent appearance and completely resistant to boil-

ing water. The tensile strength of small test blocks was 1000 p.s.i., and the compressive strength was 2500 p.s.i.

Raw material cost is estimated now at about \$50 per ton. One ton will produce about 1000 square feet of 3/4-inch board.

Dry filter cake can also be used to make a somewhat less satisfactory product.

MUSHROOM CULTURE ON CANE BY-PRODUCTS

Following a report by Block and Tsao, in Florida, an attempt was made to cultivate the edible warm-climate mushroom, *Pleurotus ostreatus*, on bagasse, bagasse compost and cane trash. Inoculation of the fungus into sterilized or unsterilized fertilized media failed to produce satisfactory molds. At the optimum temperature of 75° to 80° F., beds soon be-

came contaminated with other microorganisms which quickly destroyed the oyster fungus. The use of sawdust and oatmeal media studied by Block and Tsao, also proved unsuccessful. Completely sterile conditions would be required to produce satisfactory mushroom growth. This project was the cooperative effort of the Pathology and Organic Chemistry Departments.

VARIETIES

THE 1956-1957 CROSSING SEASON

The crossing season began on November 16, 1956, and ended on January 11, 1957. Tasseling in the Kailua breeding plots was even heavier than usual and weather during crossing operations was generally favorable. As a result, the past crossing season proved to be one of the best in recent years. Table 7 lists the type and number of crosses made.

Late-tasseling varieties are almost without exception light tassellers. A new "late-season" melting pot was initiated during the past season to permit intercrossing of those varieties which come into flower late and which provide so few tassels as to preclude their use in bi-parental crosses.

Germination of the fuzz was good and this, together with the favorable factors noted above, enabled the Genetics Department to supply the substations with large numbers of seedlings from new and promising combinations.

Steam sterilization of seedling flats prior to planting was supplanted this year by methyl bromide fumigation. Techniques worked out with the cooperation of the Pathology and Buildings and Grounds Departments have resulted in marked labor economy with no sacrifice in effectiveness of sterilization.

TABLE 7
Number of Crosses Undertaken During 1956-57
Crossing Season

General melting pot crosses.....	1,954
Leeward melting pot crosses.....	695
Windward makai melting pot crosses.....	640
Windward mauka melting pot crosses.....	323
Q.R. melting pot crosses.....	248
Late-season melting pot crosses.....	310
Bi-parental crosses.....	615
Field crosses.....	74
Total.....	4,859

PRELIMINARY TESTING AT THE REGIONAL STATIONS

During the past year, the revisions in the testing program, discussed in the 1956 report, have gradually been put into effect. This has resulted in more effective utilization of the land available for preliminary testing. Comparisons of the 1957 and 1956 totals in Table 8 show that while the number of 5x10 and 10x20 plots was reduced, the increase in numbered 5x3 and 20x20 plots has more than compensated for the aforementioned reductions.

HC&S on Maui has established four preliminary testing stations of approximately four acres each. These stations are integrated into the regional station testing program, thus greatly increasing the scope of the early testing of seedlings under leeward conditions. Representing four somewhat different environments, these stations will process the 5x3 and 5x10 stages. The 20x20 and 40x40 stages of testing will be accommodated in appropriate plantation fields.

VARIETY TESTING ON THE PLANTATIONS

Table 9 shows the number and distribution by island, of preliminary tests installed by the plantations during the past year. The only item showing no increase over 1955-1956 is the number of 10x15 and 10x20 tests installed on the island of Hawaii.

Table 10 lists the varieties which are being tested in replicated trials installed by the plantations during the past year. The appreciable increase in replicated

testing may be attributed to two factors. First is the need to find suitable replacements for 38-2915 because of its red rot susceptibility, and for other varieties suspected of showing signs of yield decline. Second is the widespread adoption of the augmented block designs which permit a replicated test and a 40x40 preliminary yield trial to be combined in a single test with a saving in number of plots. The unreplicated

TABLE 8
Plantings Made in 1957 at Regional Stations

Regional Stations	No. of Flats (No. of Seedlings per Flat 100-1000)	Unnum- bered 5' x 3' No. of Sdlg. Plots	Numbered 5' x 3' No. of Seedling Plots	5' x 10' No. of Seedling Plots	10' x 20' No. of Seedling Plots	20' x 20' No. of Seedling Plots	40' x 40' & 30' x 30' No. of Seedling Plots
Kailua Field Laboratory.....	2,046	1,254	38	394	.....	.....	.....
Waipio Substation.....	1,461	13,214 ¹	3,398	3,289 ²	.....	463 ³	.....
Helemano Variety Station.....	.....	5,091 ³	2,601 ⁴	831	.....	85	.....
Hilo Variety Station.....	747	2,099	3,182	1,014	92	16	13
Hilo Mauka Variety Station.....	408	4,674	455	1,097	21	.....	.....
Hamakua Makai Variety Station....	245	3,661	1,345	967	105	8	26
Hamakua Mauka Variety Station...	186	4,778	542	991	98	.....	22
Kohala Variety Station.....	.....	1,662	1,144	655	85	.....	24
Kau Variety Station.....	602	4,214	1,370	804	94	.....	21
Lihue Variety Station.....	481	2,255	1,923	169	97	14	20
McBryde Variety Station.....	545	9,172	4,079	967	.....	112	.....
H. C. & S. Co.*.....	200	2,515	7,639 ⁵	21	.....	21	.....
1957 Total.....	6,921	54,589	27,716	11,199	592	719	126
1956 Total.....	6,476	50,989	2,849	17,091	609	311	135

* H. C. & S. Co., 10x20 and 40x40 plantings tabulated on Table 9.

¹ 10,117 unnumbered 5x3 plots—late 1956 plantings already selected.

² 1,605 5x10 plots—late 1956 plantings already selected.

³ 3,298 unnumbered 5x3 plots—late 1956 plantings already selected.

⁴ 83 numbered 5x3 plots—late 1956 plantings already selected.

⁵ 1,078 numbered 5x3 plots—late 1956 plantings already selected.

⁶ Includes 159 seedlings planted in late 1956.

Omitted from table:

(a) Breeding and spreading canes at Kailua Field Laboratory.

(b) Field nurseries under special conditions on plantations:

Kohala 179 flats

Hutchinson 100 flats

279 flats

(c) Unnumbered 5x3 plots under special conditions on plantations:

Hawaiian Agric. Co..... 454 plots

Hutchinson 728 plots

(d) 5x7 plots under special conditions on plantations:

Hawaiian Agric. Co..... 61 plots

Hutchinson 107 plots

portions of the augmented block trials are included in Table 9, the replicated seedlings in Table 10.

The expansion of yield testing on the plantations emphasizes the need for improvements in harvesting techniques to ensure maximum information per dollar spent. An erroneous or "fluke" result from a test can be costly from two standpoints. Such an error

may lead to needless and expensive retesting if the yield in question happens to be erroneously high. On the other hand, it may lead to discarding a potentially valuable variety if the erroneous yield is lower than the true potential of the variety. For reliable results from yield trials, careful supervision and attention to detail are essential.

DISTRIBUTION OF SEED

In addition to their preliminary testing functions, the regional variety stations serve as seed distributing centers. Those seedlings which, in preliminary tests

continue to show progress, are spread by regional stations in seed nurseries for distribution to plantations for further testing. Details are shown in Table 11.

TABLE 9
Number of Preliminary Tests Installed by Plantations 1956-1957
(Fiscal year ending June 30)

Type of Test	Kauai	Oahu	Maui	Hawaii	1957 Total	1956 Total
10x15 and 10x20.....	24	12	9	28	73	68
30x30 and 40x40.....	23	13	14	29	79	49

TABLE 10
Replicated Variety Tests Installed by Plantations
(July 1, 1956 to June 30, 1957)

Variety	Kauai	Oahu	Maui	Hawaii	No. of Entries Total
37-1933.....	11	8	7	....	26
38-2915.....	....	11	7	....	18
4443.....	....	....	....	2	2
39-5803.....	....	3	....	....	3
7028.....	11	....	....	....	11
41-3340.....	....	....	....	5	5
44-2772.....	....	....	....	12	12
3098.....	....	1	....	12	13
45-2608.....	1	5	4	....	10
2708.....	1	....	....	....	1
2860.....	2	....	....	....	2
46-564.....	....	....	....	1	1
48-152.....	....	1	....	....	1
546.....	1	....	....	3	4
3845.....	....	2	....	....	2
4178.....	2	5	2	....	9
4605.....	9	....	....	....	9
4646.....	2	8	1	....	11
49-5.....	11	3	4	22	40
104.....	2	1	4	9	16
134.....	3	3	....	1	7
612.....	....	....	....	5	5
3533.....	....	....	3	....	3
3961.....	1	....	2	....	3
50-723.....	....	....	....	3	3
2606.....	1	....	....	....	1
7209.....	....	1	3	....	4
51-2530.....	4	....	....	....	4
4964.....	1	....	1	....	2
Totals for:					
1956-1957.....	63	52	38	75	228
1955-1956.....	48	39	11	76	174
1954-1955.....	14	13	2	63	92

TABLE 11
Seed Shipments to Plantations
(July 1, 1956 to June 30, 1957)

Source	For Seed Nurseries—Tons	For 10x10 No. of Plots	For 30x30 and 40x40 No. of Plots
Waipio Substation	15.53	1,697	32
Waimano Mauka Variety Station.....	.38	45	....
Helemano Variety Station.....	....	3	14
Hilo Variety Station.....	4.46	398	3
Hilo Mauka Variety Station.....	....	41	....
Hamakua Makai Variety Station.....	.18	957	....
Hamakua Mauka Variety Station.....	.06	142	....
Kohala Variety Station.....	.05	....	....
Kau Variety Station.....	....	29	....
Lihue Variety Station.....	.13	49	....
McBryde Variety Station.....	7.80	58	12
Totals	28.59	3,419	61
Total 1955-1956.....	10.46	3,859	108

CYTOLOGICAL INVESTIGATIONS

Investigations on the cytogenetics of sugar cane continue under the cooperative USDA-HSPA project. During the past tasseling season, Dr. Sam Price collected pollen mother-cell material for cytological study from the breeding collection at the USDA Sugar Crops Field Station, Canal Point, Florida.

Determination of chromosome numbers in clones in

the USDA and HSPA breeding collections has been centered on wild relatives of sugar cane collected by A. J. Mangelsdorf in Thailand in December 1955, and on F_1 hybrids obtained from crossing noble canes with related species. Dr. Price has published two papers dealing with the cytology of F_1 interspecific hybrids of sugar cane.

1957 NEW GUINEA EXPEDITION

John N. Warner of the Genetics Department and Carl O. Grassl of the Sugar Crops Section, USDA, left Hawaii on February 25, 1957, on an expedition sponsored by the Plant Introduction Service, USDA, to collect new breeding material (nobles and wild canes) from areas of New Guinea hitherto unexplored for sugarcane germ plasm. Also on the agenda was the collecting of other miscellaneous plants of interest. Cooperating institutions were the Experiment Station, HSPA, and the Bureau of Sugar Experiment Stations of Queensland.

The expedition's main effort was directed toward the collection of native chewing canes and their wild relatives in the lowlands of the Sepik River and Ramu

River districts. In addition, surveys and collections were made in other lowland as well as highland areas not previously sampled (Figure 46). A month was spent in Dutch New Guinea, a week in the British Solomons, and two and a half months in Australian New Guinea.

In the course of the expedition, 192 noble canes were collected, plus 42 clones of *Saccharum robustum* and 26 of *S. edule* (Figure 47). In addition, there were 39 seed collections of *S. robustum* and 23 of *S. spontaneum*. The clonal material collected is in quarantine plantings in Queensland and in Beltsville, Maryland. Seed collections are being germinated at Beltsville and at the Molokai Quarantine Station.



Figure 46. Native village of Komperi in the Highlands. The large men's house is surrounded by family huts and subsistence gardens of sugar cane, sweet potatoes and bananas.



Figure 47. *S. robustum* on banks of Murnass River, near Madang. Mr. Grassl is studying the flower structures.

ACREAGE CENSUS OF CANE VARIETIES

The area planted during 1956 totalled 30,460 acres, or 13.93 per cent of the total cane area. This represents a slight increase over last year's planting, but it is still far below the peak of 1951 when plantings amounted to 20 per cent of the total area.

For the sixth consecutive year, 44-3098 led in acreage planted. Of the 8763 acres planted to 44-3098, 8577 acres were on the island of Hawaii. In second place was 38-2915 with 7009 acres planted, for the most part on Oahu and Maui. 37-1933 with 4880 acres came third. Of this acreage, about three-fifths was planted on Kauai, the remaining two-fifths being divided equally between Oahu and Maui. 39-7028 remains in fourth place with 4260 acres, localized on windward Kauai. 44-2772 was fifth with 2462 acres, all on Hawaii and, for the most part, in the middle and mauka lands. 41-3340 came sixth with 571 acres planted in the droughty lands of Hamakua, Kohala and Kau.

Of particular interest are two newcomers, 49-104

and 49-5 in seventh and eighth places with 478 and 465 acres, respectively. These plantings were localized on Hawaii. Substantial plantings of these two canes are now under way on the other islands as well.

In terms of total acreage in the Territory, 37-1933 with 67,136 acres remains the leader in spite of a loss of 2570 acres during the year. 44-3098 in second place gained 3104 acres to bring its total to 60,798 acres. If maintained, this trend will soon carry 44-3098 into first place. 38-2915 in third place with 41,805 acres, gained 3172 acres during the year. However, the upward course of this variety has now been halted by the red rot threat. 39-7028 in fourth place gained 3052 acres, bringing its total to 14,864 acres. 32-8560 and 32-1063 in fifth and sixth places, respectively, continued their decline; each lost about 3000 acres during the year. 44-2772 in seventh place gained 2500 acres, bringing its total to 4919 acres. The 1957 census will no doubt record a further rise in the acreage of this variety.

THE VARIETY PICTURE—1957

The variety 38-2915 has suffered serious damage from red rot on windward Kauai, and the spread of the disease to fields of this variety on Oahu, Hawaii and leeward Kauai has created a potentially dangerous situation. In the 1956 variety census, 38-2915 was reported as occupying over 40,000 acres. Plantings of 38-2915 in warm, dry areas have thus far suffered little or no damage. In the cool, wet mauka lands, however, 38-2915 needs to be replaced as rapidly as possible with resistant varieties. Fortunately, most of the competitors thus far tested for red rot susceptibility prove to be resistant.

On Hawaii, even before the appearance of red rot, 38-2915 was being displaced by 44-2772. The once extensive plantings of 38-2915 on windward Kauai have been almost entirely replaced by 39-7028. In the mauka lands of the leeward plantations, however, the situation is far from satisfactory. A number of promising candidates are available, but they have still to prove themselves in adequate yield trials.

The major leeward variety, 37-1933, has shown signs of decline in some areas. These indications of lack of permanence in variety performance emphasize the danger of relying upon a single variety in the face of a dynamic pathogen complex. One-crop farming provides excellent opportunities for the development of new and more virulent races of pathogens, which must in turn be countered with new and more resistant varieties.

Among the newer canes, 49-5 holds the spotlight. It is remarkable for its good juice record and its thrifty growth over a wide range of conditions in both the leeward and the windward districts. It is impressive in its capacity to respond to favorable conditions, but it appears to be rather sensitive to hardship. On the island of Hawaii, it has performed well in yield trials, particularly in the better lands, on the strength of which it has been spread to many hundreds of acres.

On Maui, Oahu and Kauai, 49-5 has been pitted against 37-1933 and 38-2915 in many yield trials, only a few of which have thus far been harvested. The issue is therefore still in doubt. Meanwhile, 49-5 is being spread rapidly in all districts on the basis of its well established record of good juices and its excellent appearance. It must be recognized that spreading in the absence of adequate yield data involves an element of risk. Everything considered, however, the

spreading of 49-5, at least to the point of developing an adequate seed supply, would appear to be well justified, particularly where a replacement variety is urgently needed.

The following summary is based upon the yield data from replicated tests and preliminary trials (30x30, 40x40) harvested at the regional variety stations and on the plantations. The major ecological zones are considered in geographical order.

Windward Kauai—Mauka Unirrigated

39-7028 remains the major variety. 45-2120 and 48-4605 are strong competitors and 39-4753 may be considered a standby. 38-2915, because of its susceptibility to red rot, has declined rapidly in acreage.

Candidates for testing: 49-5, 49-3404, 49-4638, 50-5028, 50-5217, 50-6877, 51-2530, 51-3637, 52-3157 and 52-3678.

Windward Kauai—Irrigated

39-7028 continues to gain in acreage at the expense of 37-1933, whose performance in this region has this year been disappointing. As test data accumulate, a number of new competitors are asserting themselves. Included in this group are 45-2608, 46-3037, 48-546, 48-4605, 48-4646, 48-4899, 49-5, 49-134 (for short-cropping), 49-3533, 49-3945 and 50-2606. 45-2708 remains a standby in fertile areas under long cropping.

Other candidates for testing: 45-2860, 46-169, 48-4046, 49-3404, 49-4060, 50-2524, 50-2542, 50-5028, 50-7209, 51-2279, 51-2530, 51-3482 and 51-4336.

Leeward Irrigated—Mauka and Middle Belt

Until recently, 38-2915 has been gaining in acreage at the expense of 37-1933 and 44-3098. With the spread of red rot disease to mauka areas of leeward Kauai and Oahu, this trend has lost its momentum. 38-2915 continues to produce excellent yields in dry, warm areas, but replacements are needed for the cool mauka fields.

The performance of 37-1933 has been somewhat spotty of late, with yields well maintained in some areas and disappointing in others.

The following have equalled or outyielded 38-2915 and 37-1933 in a number of trials: 45-2608, 45-2860, 48-4178, 49-5, 49-104, 49-134, 49-3533, 50-2036 and 50-7209.

47-2060 and 48-152 at Waialua, and 48-4046 at McBryde Sugar Company, Ltd., Kahuku Plantation Company and HC&S, have performed well in yield trials.

Other candidates for testing: 47-2976, 48-3845, 48-4046, 49-118, 49-3404, 49-3666, 49-3637, 49-3736, 50-6062, 51-2530, 51-4336, 51-4448, 51-5017, 51-8194 and 52-4511.

Leeward Irrigated—Makai

37-1933 remains the major variety, but 38-2915 has gained acreage in Maui growth failure areas, in the coral flats of Ewa, and in the poorer lands of this region. 39-5803 continues to attract favorable attention in the marine flats of Kekaha and Ewa.

44-3171 is approaching commercial status at Kahuku. 47-2060 may be considered a standby at Waialua and Oahu Sugar. 49-3533 has repeatedly equalled or outyielded 37-1933 in the better lands. Because of its excellent juices, 48-4178 is of interest for rank growing, poor juice situations. 49-5, 49-104, 50-2036, 50-7209 and 51-8194 are strong competitors.

Other candidates for testing: 48-514, 48-3845, 49-5, 49-118, 50-2010, 50-2542, 50-2606, 50-4508, 50-6062, 51-2530, 51-4212, 51-4378, 51-4964, 51-5017 and 52-2015.

Hamakua and Kohala—Mauka

44-2772 continues to gain in acreage replacing 38-2915. 38-4443 remains without much change in the extremely poor mauka areas. 46-525 and 46-564 are standbys.

Other candidates for testing: 41-1045, 49-612, 50-723 and 50-2746. 49-612 in particular appears to have good possibilities as a long-cropper.

Hamakua and Kohala—Middle Belt

While 38-2915 still occupies a considerable portion of this region, it is gradually giving way to 44-2772. This trend will probably accelerate with the spread of red rot disease into this region. 44-3098 in good lands and 41-3340 in the dry lands of Kohala remain the standards in their respective areas. 49-5 and 49-104 are strong competitors and are being spread rapidly. 45-2120 may be classed as a standby.

Other candidates for testing: 41-1045, 45-2654, 49-134, 50-2542 and 51-760.

Hamakua and Kohala—Makai

41-3340 in droughty areas, 44-3098 in good areas,

together with some 38-2915, are the standards in this region. 45-2120 and 46-564 are good standbys for droughty areas. 49-134 has done well under non-droughty conditions. 49-5 is a versatile and impressive competitor and is being spread rapidly. 49-104 also shows considerable promise.

Other candidates for testing: 48-527, 48-546, 49-118 (at Honokaa Sugar Company only), 49-823, 50-723 and 51-735.

Hilo—Mauka

44-3098 is still strong in this region and is a difficult standard to equal. 44-2772, 49-5 and 50-723 are the major competitors.

Other candidates for testing: 50-2036.

The lack of competitors in this region reflects the need for a more extensive testing program. To meet this need, a new station has been established in the Hilo mauka area.

Hilo—Middle and Makai

44-3098 is the standard variety. 48-3038, 49-104, 49-134 and 50-723 have done well in yield trials. On the basis of its encouraging performance in yield trials, 49-5 is being spread rapidly.

Other candidates for testing: 49-3404 and 50-2542.

Kau—Mauka

The standard is 44-3098, with limited areas of 46-564 in the poorer lands.

Other candidates for testing: 49-3646.

A more extensive testing program is needed to identify canes that can meet the rigorous climatic conditions of the higher elevations.

Kau—Middle Belt

44-3098 is the major variety, with some acreage in 38-2915. 49-5 and 49-118 are competitors, although the carry-over ability of the latter under long-cropping is still in doubt.

Other candidates for testing: 48-3038, 50-723, 51-653, 51-703 and 51-3049.

Kau—Makai

41-3340 is the standard although 32-8560 still occupies a limited acreage. 46-564 and 45-2120 have done well in trials.

Other candidates for testing: 46-945, 47-2060, 49-5, 49-118 and 50-723.

GROUP TESTS EVALUATE TASSEL CONTROL METHODS

A test has recently been completed that was designed to compare the flower control and yield effects of the following treatments: drought, maleic hydrazide, CMU, Versene, extra nitrogen and plantation practice. Two or more replicates of each treatment were installed at the following plantations: Pioneer Mill Company, Ltd., Lihue, McBryde, Kahuku and Oahu Sugar.

Unfortunately, several of the fields selected did not flower heavily, a circumstance which reduced the number of useful replicates. However, even in these fields, neither rigorous drying off nor chemical sprays reduced yields, a result which is important in emphasizing the safety of the control methods.

The data have been partially analyzed by the Department of Experimental Statistics.

Table 12 shows the degree of flower control resulting from the treatments. With the exception of the failure of maleic hydrazide at McBryde, the chemicals controlled flowering to a degree comparable to drought. The extra nitrogen did not do a satisfactory job.

In one area at Kahuku, drought control was a definite failure due to rains and high water table.

The following summary is taken from the Statistical Summary Report.

1. The average tassel counts in Table 12 indicate that the treatments fall into two groups, those reducing tasseling to a low level being drought, maleic hydrazide and CMU. Versene appears to belong in this group, also, although it was applied in only two of the four experiments of the A set.

2. A combined analysis of four experiments where all treatments had a chance to control tasseling, showed no real differences in TCPA, but the treatments significantly ($P < 0.01$) affected P%C and TPA.

3. The Location x Treatment interaction was significant ($P < 0.01$) in TCPA and TPA. An inspection of data indicates that this came about from repression of cane growth by maleic hydrazide and by CMU in isolated experiments, as well as from the pronounced treatment responses recorded at Lihue in contrast to other locations.

4. The presence of significant interactions suggests caution in interpreting general treatment means. It is obvious that the Lihue ranking of treatments is reflected in the treatment order determined by the means over four experiments.

5. From the B set of experiments, omitting Kahuku (a), it appears that no serious reductions are brought about by application of the treatments in the absence of tasseling.

Extensive tests at Wailuku Sugar Company have shown that, as compared with young cane, older cane requires longer periods of drying off to prevent flowering. An experiment at Ewa confirmed those results and added information on soil moisture. This showed that cane six months old reduced the soil moisture much more rapidly than did cane 17 months old.

The heavy flowering of the X plots at Ewa was associated with soil moisture well above the calculated wilting point of the soil. For good control, the soil moisture should be reduced to the calculated wilting point of the soil early in September.

FLOWERING AFFECTS BOTH YIELD AND QUALITY

A very complete study of flowering effects on cane quality was made by the Agronomy Department in cooperation with the Waipio Substation and Kahuku. First season tasseling was suppressed by spraying eight pounds per acre of CMU in CADE made with non-

phytotoxic oil. Results are shown in Tables 13 and 14. CMU controlled first season tasseling well (6.16 per cent in contrast to 39.31 per cent in checks). Stalk census data in Table 13 explain the poor juice purity and low P%C of the check plots given in Table 14.

DOES TISSUE MOISTURE CORRELATE WITH FLOWERING?

Earlier studies at the Makiki Station indicated that sheath moisture was not a reliable index of the critical moisture level for flower initiation. One reason for this is the sensitivity of sheath moisture to nitrogen

and age. The same criticism applies to 8-10 stalk moisture as a flowering index. In the Ewa experiment cited above, 8-10 moistures were run at weekly intervals. It was found that the moisture of the older cane,

TABLE 12
Average Tassel Count Per 100 Stalks

Treatment	A ¹					²	B ²	³
	Pioneer (b)	Lihue	McBryde	Kahuku (b)	Mean	Oahu	Pioneer (a)	Kahuku (a)
Drought	2.8	0.0	1.2	8.5	3.1	1.3	1.0	33.5
MH	2.1	3.0	24.2	9.5	9.7	1.5	1.4	5.5
CMU	5.9	0.0	4.2	3.0	3.3	1.5	0.8	7.0
PP	15.5	13.0	32.5	57.0	29.5	2.3	5.7	55.5
100# N.....	9.6	16.0	26.0	37.0	22.2	2.3	1.4	36.5
Versene	1.5	.....	.....	4.0	.....	1.3	0.6	3.5

¹ The A group of experiments had 13% or more tasseling in plantation practice.

² Experiments in which controls tasseled very little.

³ Rain and high water table prevented drought control.

TABLE 13

Stalk Census Studies at 13, 16, and 23 Months at Kahuku When First-Season Tasseling Had Been Reduced by Applications of Eight Pounds CMU in CADE of Non-Phytotoxic Oil

Measurements	CHECK			CMU		
Stalks per foot of row	13 mo.	16 mo.	23 mo.	13 mo.	16 mo.	23 mo.
Sound primary stalks.....	4.55	4.13	2.83	4.69	4.14	2.95
Sound 1st season suckers.....	.49	.93	.55	.31	.68	.30
Sound 2nd season suckers.....	0.0	0.0	.15	0.0	0.0	0.0
All sound stalks.....	5.04	5.06	3.53	5.00	4.82	3.25
% sound primary stalks.....	83.54	74.35	47.03	84.98	84.06	70.78
% sound no top primary stalks.....	5.90	3.29	8.91	7.39	1.03	5.84
% sound 1st season suckers.....	9.58	17.41	10.89	6.16	13.88	7.79
% sound 2nd season suckers.....	0.0	0.0	2.97	0.0	0.0	0.0
% dead primary stalks.....	.98	4.47	25.25	1.48	1.03	14.29
% dead 1st season suckers.....	0.0	.47	3.96	0.0	0.0	1.30
% dead 2nd season suckers.....	0.0	0.0	.99	0.0	0.0	0.0
% tasseled stalks.....	39.31	34.12	49.0	6.16	6.17	39.6

TABLE 14

Cane Samples of Variety 37-1933 Taken at 23 Months of Age for Juice Quality Studies

Spl. No.	Plot No.	Wt. Gms.	Fiber Wt. Gms.	Juice Pol	P% C	F% C	TC/TP	Purity
	(Pali)							
1	CMU #1.....	102.7	162.8	5.45	15.25	15.85	6.6	90.53
2	CMU #2.....	975.8	144.4	5.22	15.20	14.80	6.6	92.23
3	X #1.....	934.0	144.1	3.93	11.78	15.43	8.5	82.74
4	X #2.....	949.6	148.1	4.27	12.64	15.60	7.9	84.06
	(Flat)							
5	CMU #1.....	931.8	150.1	4.99	14.95	16.11	6.7	91.06
6	CMU #2.....	1,001.0	160.3	5.58	15.89	16.01	6.3	92.08
7	X #1.....	967.2	154.4	4.00	11.67	15.96	8.6	79.37
8	X #2.....	986.2	151.4	4.57	13.18	15.35	7.6	88.74

receiving regular irrigation and flowering heavily, was much lower than that of the young cane in which flowering was completely controlled. Hence, there is no absolute 8-10 stalk moisture level associated with lack of flowering.

However, the younger stalk joints may tell another story. In the course of investigating moisture as a growth index, it has been found that stalk joints #4 and #5 have moisture contents largely independent of nitrogen. The work of last fall at Makiki showed that if the normal 91 per cent moisture of the #4 and #5 joints fell to about 85.5 per cent by September 10, few tassels were formed. The interrelation between nitrogen, moisture and flowering is illustrated in Table 15 and Figure 48.

The following conclusions may be drawn from the data in Table 15.

1. August 10, the recommended date for the last regular round of irrigation, was not early enough to give good control at Makiki last fall. The poor control was due to some rains in September. The earlier start on August 3 gave distinctly better control.
2. Water can be put back on September 14 without much loss of control as compared with September 21.
3. Nitrogen alone gives negligible reduction in flowering. There may, however, be a shift from fully emerged tassels to more false tassels and bunch top. Observed at a distance, this would give the appearance of considerable control.
4. Added nitrogen increases the effectiveness of

control by drought. The only treatment resulting in nearly complete control was the early withdrawal of water combined with extra nitrogen. This effect shows such promise as a means of extending the control of flowering to greater ages that most of the Makiki plots will be devoted to this phase of the work this season.

After fulfilling the requirement that water be withheld long enough to reach the wilting point early in September, the time of return of water to the field is of great importance. The cumulative evidence from Makiki, Wailuku, Kilauea Sugar Company, Ltd., and Waialua, indicates that returning water before September 14 results in less perfect control of flowering.

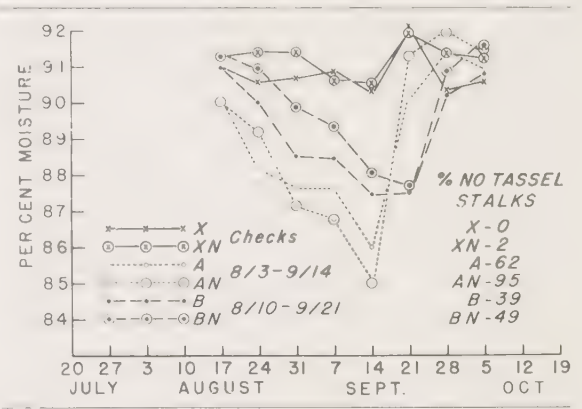


Figure 48. Effect of withholding irrigation on moisture content of joints 4 and 5, and on tasseling. The moisture in joints 4 and 5 correlated with flower initiation in September.

TABLE 15
Effects of Nitrogen and Moisture on Flowering of Sugar Cane

Treatment	Plots	Dry Period	% No Tassel	% Tassel	% Flagging or Bunch Top
100 lbs. N April 1	X	.....	0	92	8
	A	8/3 -9/14	62	19	19
	B	8/10-9/21	39	35	26
	C	8/10-9/14	36	36	28
	D	8/17-9/21	26	30	44
100 lbs. N April 1	XN	.....	2	74	24
	AN	8/3 -9/14	95	0	5
	BN	8/10-9/21	49	17	34
100 lbs. N August 1	CN	8/10-9/14	62	2	36
	DN	8/17-9/21	66	6	28

CONTROLLING FLOWERING WITH CHEMICALS

No new chemicals were found which are equal to those already in use: CMU, maleic hydrazide and Versene.

Of especial interest were the two new hormone-like chemicals, hydroxy ethyl hydrazine (HEH) and gibberellic acid (GA). The former has striking effects on flower initiation in pineapples, and the latter affects growth habits and flowering of many plants.

Table 16 summarizes the effects of sprays on large tagged stalks of 37-1933 six months old in Septem-

ber. HEH at 0.15 per cent (the concentration effective in pineapples) had no inhibiting effect. A ten-fold increase in concentration greatly reduced flower initiation and tassel emergence, but the chemical markedly injured the plants. At the concentration used, GA had no measurable effects, but tests will be repeated this fall with larger amounts of the chemical.

Attempts with chemical sprays to induce flowering in reluctant varieties, e.g. 39-7028, growing in favorable flowering areas, were not successful.

TABLE 16
Effects of Hydroxy Ethyl Hydrazine and Gibberellic Acid on Flowering of Sugar Cane

Chemical	Concentration of Spray	Dates Sprayed	Stalks Not Initiated	Emerged Tassels	False Tassels & Bunch Top
			%	%	%
HEH	0.15 %	8/29	0	100	0
		8/22 & 9/29	0	100	0
	1.5 %	8/29	30	43	27
		8/22 & 8/29	83	0	17
GA	0.6 mg/ft. of line	8/27	0	100	0
		8/27 & 9/4	0	94	6
		9/4	3	97	0
Checks		.....	2	94	4
		.....	0	94	6

WEED CONTROL

NEW ARCADE CONCENTRATE ECONOMICAL

A new ARCADE Concentrate was developed at this Experiment Station last year and was demonstrated at both the HST and HSPA annual meetings. This development was offered to the industry as an improvement over Standard ARCADE in that it is less costly to prepare and is considerably more potent. It consists of a concentrated emulsion carrying the oil-soluble rather than the water-soluble type of the HSPA Activator. The oil-soluble form actually costs 1½ to two cents less per pound than the water-soluble compound and, in addition, due to its chemical makeup, 168 pounds of the oil-soluble compound carry the same amount of active material that is present in 200 pounds of the water-soluble compound. The over-all saving in using the oil-soluble form of the activator

amounts to about seven cents per pound.

This new concentrate also carries all of the wetting agent that is required for effective field use after it has been diluted as a field spray. Its use on the plantations enables the mixing plant personnel to dispense with two storage tanks, which are required for preparing Standard ARCADE. One of these tanks carries the APC (aqueous portion of CADE) and the other the SSA (stock solution of Activator). Since the new concentrate carries all the essentials of these two compounds, it may be diluted with water from four to eight times its volume, either in the mixing plant or in the field, prior to its application. Several plantations are now preparing and using this new concentrate. Others are considering doing so.

AROMATIC OILS IMPROVED

One of the aromatic oils now available to plantation users has, at the request of the Chemistry Department, been improved by an additional refining operation which eliminates naphthenes and a large per-

centage of tars and similar non-emulsifying fractions, which all aromatic oils of this character contain. The elimination of the naphthenes has removed the principal source of bad odor which was objectionable.

NEW CHEMICAL HERBICIDES APPEAR

During visits to the mainland this year, many manufacturers of agricultural and herbicidal chemicals, although large producers of chemicals, were found to have just recently decided to enter the herbicide field. As a consequence, quite a number of new products are now under study in the laboratories of the Chemistry Department. Several new manufacturers have undertaken to produce herbicides which are patterned after the chemical structure and composition of dalapon and Silvex, both of which have been found very effective in Hawaii. Two years ago, another manufacturer brought out a compound quite similar to dalapon, and although it behaved like dalapon for a week or 10 days after application to grasses, it lost its

staying qualities very rapidly and hence proved to be an unsatisfactory substitute.

2,3-Dichloro Sodium Isobutyrate

This year, another chemical manufacturer has produced a compound similar to dalapon. It is actually a 2,3-dichloro sodium isobutyrate. Its properties are similar to dalapon's in that it is soluble in water, systemic in action, and selective on grasses. However, unlike dalapon, it does not hydrolyze when dissolved in water. The Agronomy Department is determining whether this new compound will equal, or even approach, the outstanding properties of dalapon.

Methyl Chlorophenoxy Propionic Acid

This is a development by a British manufacturer. It is a hormone similar to 2,4-D, except that it employs the popular propionic groupings in the side chain, whereas 2,4-D uses acetic groupings. Samples of this new hormone reached the Experiment Station this fall. It may or may not be found superior to 2,4-D in the tests which are outlined for study after it has been developed as an amine concentrate in the Chemistry Department.

New, Low-Volatile Esters of 2,4-D and 2,4,5-T Phenoxy Propionic Acids

These two new esters, in which the acetic groupings in the side chain have been replaced by a propionic radical, have been developed by an American manufacturer. They will not require any extensive chemical study, and hence, after determining their general characteristics and behavior, they will be submitted to the Agronomy Department for detailed field testing.

Simazin

Simazin is a compound which may be a likely runner-up to CMU. Like CMU, it is marketed as a finely-divided, micronized powder, insoluble in water, but capable of being suspended in water by constant agitation. A water suspension of Simazin settles very rapidly unless it is kept in violent motion while being applied in the field. If the mixture is allowed to stand overnight or longer, it settles to a very hard cake—somewhat harder than that produced by a similar preparation of CMU. Two methods of overcoming this difficulty were suggested to the manufacturer. One was to employ a suspending agent similar to CPA, which was developed at this Experiment Station three years ago. The other was to obtain an oil-soluble form of Simazin which could be incorporated with aromatic oils and made up into an emulsion like ARCADE. An oil-soluble Simazin, submitted at that

time for experimental study in Honolulu, does dissolve in aromatic oils and may readily be made up into an ARCADE emulsion. Such an emulsion, diluted with water, will carry the Simazin in satisfactory suspension.

A search was made for a new and less expensive, more easily processed suspending agent which could be used on the plantations. Two such compounds were obtained and are now under study. One of them appears to be almost equal to CPA, and has the marked advantage of not requiring any previous plantation processing for use as a suspending agent in water, not only with Simazin, but also with CMU, DCMU, and several other micronized, wettable powders which will not dissolve in water, but which, without treatment, will settle to a hard cake.

2,4-Dichlorophenoxy Acetamide

2,4-dichlorophenoxy acetamide is a development of an American manufacturer, and is being sold, in limited quantities, under the trade name of "Emid." It is insoluble in water and appears to have hormone properties. It is furnished as a micronized powder containing 75 per cent of active material. It is another wettable powder formulation, and at present it appears capable of being almost perfectly suspended in water by one of the new suspending agents, described above, which are now under study in this laboratory.

2,4,5-T Sodium Ethyl Sulfate

2,4,5-T sodium ethyl sulfate, a compound with hormone characteristics and completely soluble in water, is being produced at the present time in Ohio. The manufacturer claims that this new development, although it is a hormone, will not injure sensitive vegetation upon which it may be accidentally sprayed. It becomes effective only upon contact with the soil, and is therefore offered as a pre-emergence chemical. The claims of the manufacturers have not as yet been checked, but this will be done in cooperation with the Agronomy Department in the near future.

FIELD SCREENING OF NEWER HERBICIDES

Field screening of 11 herbicides this year included six which are classified as soil fumigants, but which were also tested for their use as herbicides.

Simazin: 2-chloro-4,6-bis(ethylamine)-s-triazine

TCB: (TBA) 2,3,6 isomer of trichlorobenzoic acid

3Y9: tris-(2,4-dichlorophenoxy ethyl)phosphite

FW-450: 2,3-dichloro sodium isobutyrate

4(MCPB): 4-(2,4-dichlorophenoxy) butyric acid

ONCB: ortho nitro chloro benzene

Vapam: sodium N-methyl dithiocarbamate

EDB: ethylene dibromide

MC-2: methyl bromide plus chloropicrin

TABLE 17
Comparative Results With Five Herbicides

Chemical	Lb/A	HA Co. (49.24)	Hilo (49.25)	Ewa (49.70)	Ewa (49.73)	Kahuku (49.69)	Kahuku (49.70)	Oahu (49.79)	Oahu (49.80)	Oahu (49.82)	Waialua (49.44)
Simazin	2.5	....	....	....	....	30	....	....	....	28	65
Simazin	5.0	....	....	61+	53	41	42+	54	48	35	69
TCB	4.0	62	....	....	....	....	....	....	....	....	....
TCB	5.0	....	101	....	31	36	18	....	....	....	58
3Y9	4.0	38	....	....	....	....	....	....	....	....	....
3Y9	5.0	....	....	....	37	28	15	....	....	....	34
2,4-D BEP	4.0	39	....	....	....	....	....	....	....	....	....
2,4-D BEP	5.0	....	95	....	51	34	....	....	....	....	....
CMU	4.0	79	....	....	....	....	....	....	....	....	....
CMU	5.0	....	118	61+	50	44	42+	49	48	29	58
Check	0.0	16	55	19	22	10	13	25	11	13	35

DD: 1:3-dichloropropene + 1:2 dichloropropane
Telone: 1:3-dichloropropene

Table 17 gives the results of tests on several plantations on Hawaii and Oahu, comparing Simazin, TCB and 3Y9 with CMU and 2,4-D ester.

These data show that, on a pound for pound basis, Simazin is equally, or slightly more, effective for pre-emergence weed control as is CMU. The same trend was shown in a test at Kilauea. TCB appears slightly less effective than CMU. The 3Y9 does not rank with CMU and 2,4-D in pre-emergence control. Neither TCB nor 3Y9 have shown grass-killing qualities.

The action of Simazin on weeds is similar to that of CMU in that weeds that have emerged display

chlorotic leaf margins with progressive tissue mortality. TCB causes epinastic growth response on broad-leaved plants very much as 2,4-D does. In two tests, some effect of TCB at five pounds per acre has been observed on sugarcane germination and growth.

The herbicide FW-450 has been tested both as a pre-emergence and a grass-killing herbicide. Thus far it seems better as a grass-killer, but when applied at 10 pounds per acre in water solution, it has not equalled the grass-killing qualities of dalapon on either Bermuda grass or mixed non-rhizomatous grasses infield.

In two tests, 4-(MCPB) showed little value for use in sugar cane.

SOIL FUMIGANTS AS HERBICIDES

A number of tests to determine their values as herbicides have been conducted with the soil fumigants Vapam, ONCB, methyl bromide, ethylene dibromide, DD and Telone. Of these, the first four have shown some value for weed control when incorporated into the soil. Vapam and ONCB can be sprayed at the surface and incorporated by mechanical tillage, or can be sprinkled on the soil in a water mix and incorporated by irrigation. Methyl bromide and ethylene dibromide have been applied by injection. Methyl bromide is applied as a gas under an airtight cover.

Results have shown that minimum levels of 200 pounds per acre of Vapam and ONCB are necessary

for control of weeds. At 400 pounds per acre, both chemicals were quite effective in destroying nut-grass as well as general weed growth of both non-rhizomatous grasses and broad-leaved plants. However, the 400-pound level caused damage to sugar cane. This was more severe when the chemicals were rotorilled into the soil than when they were applied at the surface or injected and followed by irrigation.

Several plantation tests with Vapam and ONCB have shown ineffective weed control.

Methyl bromide fumes were effective in destroying seeds of Spanish needle during a 24-hour exposure. Seeds of corn were also rendered non-viable during the same period and degree of exposure.

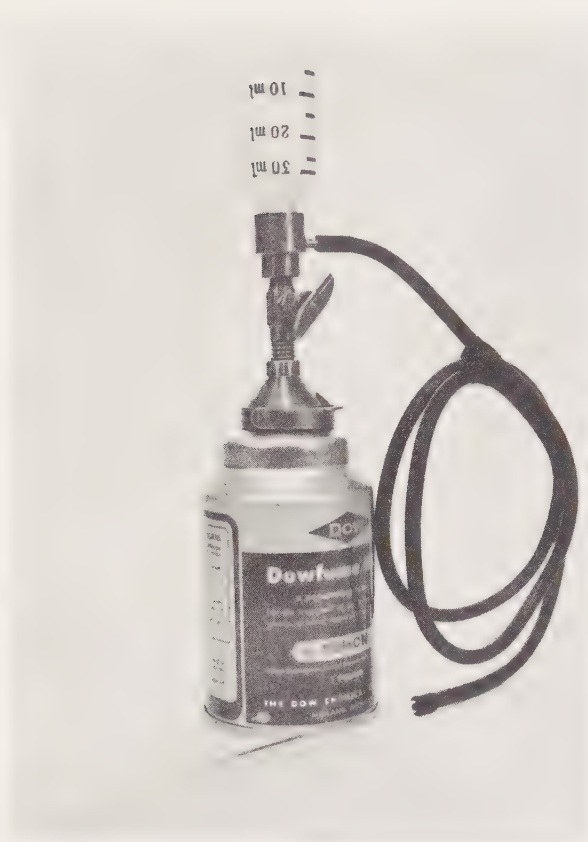


Figure 49. An applicator is clamped to the top of a one-pound can of Dow-fume MC-2 methyl bromide. The internal stem is screwed down into the top of the can to puncture the seal. When the can is inverted, the methyl bromide can be measured into the polyethylene graduated bottle by means of the needle valve, and applied with the hose and probe.

Methyl bromide in breakable vials or one-pound cans works very well for destroying small patches of nutgrass. A small applicator can be obtained for attachment to the one-pound cans for spot treatment of weedy grasses in lawns (Figure 49).

Present cost figures indicate that if the fumigants are to be practical for field scale weed control, they must also be effective on biological factors in the soil.

Diffusion tests have shown that ONCB and Vapam

are low in volatility. Tests of different methods of incorporation have shown that these chemicals are most efficient when incorporated by rototilling, and are least efficient when applied by point injection. Further testing will be focused on obtaining more complete incorporation of the chemical in the upper six inches of soil. Based on tests to date, the rototiller principle is believed to be the most satisfactory for this purpose.

DALAPON EFFECTS ON SUGAR CANE

Since the use of sodium dalapon to control grasses infield in sugar cane was begun in 1955, scattered symptoms of the chemical have appeared on crop plants in many fields. The symptoms have been shown, both by observation infield and by testing, to be in proportion to the amount of dalapon applied to the above-ground portions of the cane plants.

Symptoms of dalapon on sugar cane include:

1. Inhibition of the terminal bud, causing distor-

tion (tangle top) of the upper leaves and, to some degree, the formation of branches (lalias) from nodes below the terminal. In some cases, increased tillering has been noted.

2. Chlorotic blotching and rigidity of the chlorotic tissues as a usual accompaniment to the tangle top condition.

3. Depressed to severely depressed growth and general to heavy chlorosis, with reduced stalk size and



Figure 50. Effects of spot treatment of dalapon in concentration of 0.1 pound per gallon on grass and on variety 38-2915. When the weedy grass was sprayed, the lower portion of the sugarcane plant, shown in the center, was also sprayed. It has been repeatedly observed that no apparent damage to cane has occurred when sprays infield, totalling as high as 30 pounds per acre, are carefully applied to grasses at the base of sugarcane plants, but not to the cane.

internode length throughout the plant, are symptoms of heavy applications, while minor symptoms from light applications are slight tangle top and chlorotic blotching (Figure 50).

Where sodium dalapon has been thoroughly mixed in the soil to levels as high as 42 pounds per one-half acre foot, there have been no measurable symptoms

on germination or growth of the cane (Figures 51, 52 and 53). As high as 30 pounds per acre have been applied off cane infield without apparent symptoms.

As a result of all observations infield, as well as of all tests with dalapon, it is recommended that sodium dalapon be so applied that a minimum amount reaches the above-ground portions of the crop plants.

HERBICIDE-TOLERANT STRAINS OF WEEDS

With continued use of herbicides for controlling weeds in sugar cane, it has become increasingly evident that tolerance to some herbicides is being developed by individuals within several species. Herbicide tolerance is believed to be expressed in two ways:

1. Segregating populations of weeds, such as fireweed *Erechtites hieracifolia*, develop increased tolerance in each successive population due to reproduction by seed of the more herbicide-tolerant individuals, the less tolerant having been destroyed by the herbicide. With species which seed heavily and frequently, such tolerance could develop in a high

percentage of the population in a few years by means of a few initially tolerant individuals.

2. Clones that may be high in tolerance to certain herbicides are believed to exist within any population of species that reproduce largely by asexual means as well as by seed, such as rhizomatous grasses including broad-leaved plants, such as Bermuda grass *Cynodon dactylon*, Wandering Jew (hono hono) *Commelina diffusa*. This potential tolerance could have resulted from segregations in the past and could occur naturally in a population just as a certain percentage of non-rhizomatous individual plants may

Effect of sodium dalapon on sugar cane plants, Variety 37-1933, of near uniform height, growing on low humic (N-5) soil (Figure 51), on alluvial (V-1) soil (Figure 52), and on gray hydromorphic (H-2) soil (Figure 53).

Level of application of dalapon in six inches of soil						
Parts per million.....	Check	2.5	5.0	10.0	20.0	30.0
Pounds per acre.....	0.0	3.5	7.0	14.0	28.0	42.0



Figure 51

Color index	1.0	1.0	1.0	1.0	1.0	1.0
Root index	1.0	1.0	3.0	2.0	3.0	1.0
Root volume (cc).....	1195	1195	1090	1170	1090	1220

Figure 52

Color index	1.0	1.0	1.0	1.0	1.0	1.0
Root index	1.0	1.0	1.5	1.5	3.5	2.0
Root volume (cc).....	1195	1220	1180	1200	1090	1178



Figure 53

Color index	1.0	1.0	1.0	1.0	1.0	1.0
Root index	1.0	1.0	1.0	3.0	2.0	3.0
Root volume (cc).....	1130	1180	1145	1060	1100	1085



Color index

- 1.0 Normal green
- 2.0 Slight chlorosis
- 3.0 Moderate chlorosis
- 4.0 Severe chlorosis
- 5.0 Intense yellow-tissue mortality

Root index

- 1.0 No apparent root reduction
- 2.0 Slight root reduction
- 3.0 Moderate root reduction
- 4.0 Severe root reduction
- 5.0 Complete absence of roots



Figure 54. Dalapon-tolerant strains of Bermuda grass have been isolated from fields at Kilauea and Honokaa and compared with a non-tolerant strain from the Makiki Station in Honolulu. Note the greater effect of the different levels of treatment on the Makiki strain, which was killed by the 10-pound application and recovered partially and slowly from the five-pound application. As many as six applications of each level have not destroyed the Kilauea and Honokaa strains.

carry tolerance. It would be expected that the evolution of tolerant strains would be slower where clonal reproduction is involved than where each population develops from seed.

Clones of Bermuda grass were found at Kilauea and Honokaa with a much greater tolerance to dalapon than the clone from the Makiki Station in Honolulu, where all three were tested for their response to dalapon. Plants of these three strains treated at different levels of dalapon are shown in Figure 54. Gradings following treatment of these plants showed that the Makiki strain was completely killed by one 10-pound application of dalapon, and that recovery from a five-pound application was slow and only partial.

Neither the Honokaa nor the Kilauea strain was killed by any of the levels of five, 10 or 20 pounds per acre. In subsequent studies, these two strains were treated six times with the above levels of dalapon at intervals of two to three weeks and still have not been completely killed.

Morphological differences are quite marked be-

tween the three strains of Bermuda grass. The Makiki strain is moderately coarse and semi-prostrate with many stolons and relatively few racemes. Anthers are gray. The Kilauea strain grows erect with limited stolons, heavy seeding, and purple anthers. The plants are moderately coarse. The Honokaa strain approaches giant Bermuda grass in coarseness, grows erect and is limited in seeding. The Kilauea strain shows desirable characteristics for lawn use. Other grasses in this strain could be destroyed by dalapon due to the differential tolerance.

A 2,4-D-tolerant strain of hono hono (*Commelina diffusa*) was found in Field F001 at Paauhau. Whereas only one pound per acre of 2,4-D ester was required to kill the standard strain of hono hono at Paauhau, it required at least five pounds to control the top growth of the F001 strain. There was no effect on the plant from one pound. Greater susceptibility to 2,4,5-T and Silvex esters was found in the F001 strain. One pound per acre of each of these two chemicals was sufficient to control top growth adequately, and



Figure 55. Plants of a 2,4-D-tolerant strain of hono hono *Commelina diffusa* from Field F001 at Paaauhau Sugar Company are shown in comparison with the standard type, the two strains being considered different genetically. The leaves of the F001 plants are shorter and rounder than those of the regular type, the internodes are shorter, and, in general, the plants are smaller. Note the tolerance to one pound of 2,4-D. There was only slight differential tolerance of the two strains to 2,4,5-T and Silvex.

five pounds per acre completely killed the plants. The test plants are shown in Figure 55.

Morphological characteristics were different in the two strains, with the F001 strain having smaller, rounder leaves and shorter internodes than the standard strain.

In the plantation weed control program, the use of 2,4-D was not satisfactory in controlling the hono hono in Field F001. The tolerant strain continued to spread. It was brought under control and destroyed with 2,4,5-T. Only a few plants can be found at present.

SPECIALIZED CONTROL OF CERTAIN WEED SPECIES

Although the herbicidal control of weeds in general in sugar cane has been quite successful for several years, there are a few species that require special practices. This is in part due to the fact that the use of 2,4-D, and other growth regulator types of herbicides is restricted because of the hazards of spray drift to

truck farming or orchard areas. This is due in part also to an increasing level of tolerance to 2,4-D and related herbicides.

Some of the species that either require or may require special attention are listed with the herbicide suggested by tests to date.

Wild passion fruit <i>Passiflora pulchella</i>	Silvex
Mignonette vine <i>Boussingaultia baselloides</i>	2,4,5-T and Silvex
Fireweed <i>Erechtites hieracifolia</i>	2,4-D ester + oil
Large crabgrass <i>Cyperus esculentus</i>	2,4-D ester
Wild Caladium <i>Caladium bicolor</i> var. <i>albomaculatum</i>	2,4-D or 2,4,5-T
Dalapon tolerant strains of Bermuda grass <i>Cynodon dactylon</i>	Repeat oil or CADE, heavy CMU
Hono hono <i>Commelina diffusa</i>	2,4,5-T

CONTROL OF WEEDS BY FISH AT KEKAHA

The first tests with *Tilapia mossambica* started at Kekaha on April 15, 1955, according to H. M. Hee, Plantation Weed Control Superintendent. Since that time, over 75,000 fish have been stocked with great success in the extensive ditch system.

This herbivorous fish is a species within the Sunfish family that was introduced to Hawaii from South Africa by the Territorial Board of Agriculture and Forestry. It is prolific, spawning at intervals as short as six weeks, depositing anywhere from 50 eggs when young to as many as 2000 eggs when older.

The *Tilapia mossambica* individuals thrive in either fresh or brackish, clear or muddy water. Through the

process of burrowing in the bottom of the ditches to form saucer-shaped spawning nests, it disturbs and destroys the roots of aquatic plants. This, in addition to the herbivorous nature of the fish, destroys the vegetation including weedy grasses, submerged and emergent aquatics, and algae.

Whereas the cost of ditch weed control at Kekaha rose steadily to a total of \$5,194.06 for chemicals and labor in 1954, that cost, due to the fish, was reduced to \$25.25 in 1956 and to a negligible figure in 1957.

Another species of this fish, *Tilapia zilli*, introduced by the Board of Agriculture and Forestry, promises to be effective in ditches heavily infested with grasses.

SPRAY EQUIPMENT IMPROVED

Several plantations have replaced their infield supply units this year with new tanker trucks of the self-contained type. These units carry tanks with capacities of 1500 to 1800 gallons in two compartments that can be operated independently so that two different solutions can be carried if desired. The capacity is great enough to supply the gang for an entire day. Agitators have been provided to handle wettable powders, and hoses will reach at least 1000 feet infield. The units have storage room for the pressure knapsacks and extra equipment, and are also provided with seats for the spray men during moves to the field or from field to field.

Another double-tank pressure knapsack assembled from the F-1 tanks (1000 cubic inches) has been developed in cooperation with Sasaki Welding Shop

to utilize oxygen tanks that can be obtained on the surplus market (Figure 56).

A new type of jeep-truck-mounted sprayer for field edge and roadside treatment was constructed by Kauai Development Company for Lihue (Figure 57).

A small portable power unit for infield or general spraying was mounted on a "Merry Tiller" tractor (Figure 58). This unit, while too cumbersome for spraying in irrigated fields, may have some use under unirrigated conditions. It makes a compact and readily portable power unit for general spraying. The liquid pressure is provided either by pump or by pressurizing the tanks with air.

The "Merry Tiller" tractor has found other uses in the industry, particularly for replanting and as a small row-type rototiller.

CHLORO-COSANE

Two types of Cosanes were obtained, one of which is claimed to be an unusually effective sticker when added to sprays for application to growing weeds.

The other is recommended as an emulsifier. Both are very inexpensive, but may be found useful after completion of laboratory studies.



Figure 56. The double-tank pressure knapsack consists of two F-1 tanks arranged with parallel connections. The tanks are made of reinforced stainless steel and have a capacity of 1000 cubic inches. The unit weighs 29.5 pounds when empty, and carries 5.25 gallons when liquid is injected into the tank using initial air pressure of 30 pounds to 100 pounds total. The unit has a pressure gauge, a safety valve and a tank valve at the top, with the injector pressure regulator and the hose at the bottom.

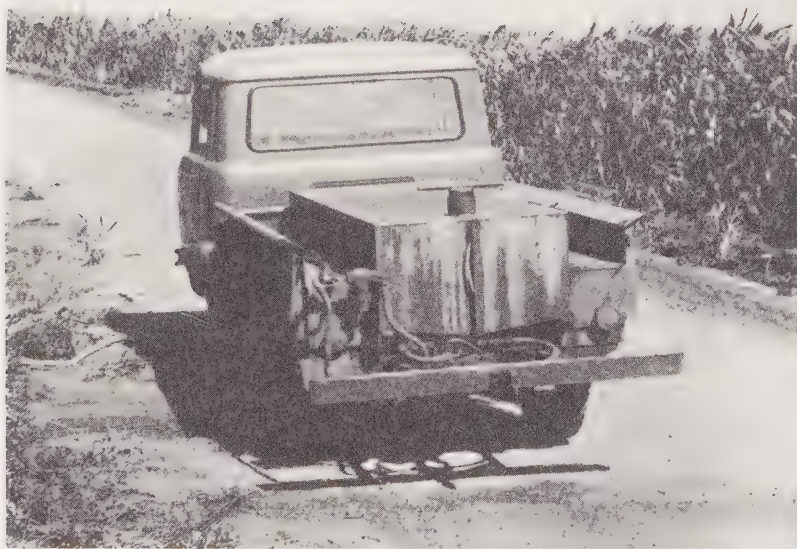


Figure 57. The spray equipment mounted on a jeep truck was built for field edge and roadside spraying for Lihue. The stainless steel tank is fitted to the truck box. A Hypro 7500 pump delivers spray solution to the TOC nozzle mounted on the left side near the operator's seat. Controls for angle of spray and a quick-opening valve are mounted inside the cab, readily accessible to the driver. The truck has a governor for calibrated speed. A spray swath of 10 to 21 feet can be covered.



Figure 58. A sprayer, built on a Merry Tiller tractor, has two G-1 stainless steel tanks (2100 cubic inches) mounted in line with pump and hose attachments, on the basic power unit. The unit is designed to utilize the pump for building liquid pressure, or for pressurizing the tanks of an in-field supply unit. Interline spraying, with the weight carried on the tractor instead of by a man, was the main objective, but the sprayer has proved too cumbersome for use in irrigated fields. It may be useful under unirrigated conditions. Its main value is as a relatively small, compact power unit for general spraying.

TRAINING OF PERSONNEL



Figure 59. Assistants-in-Training for Agriculture, 1957-1959: William R. Smythe, Charles Finley, W. D. Balfour, Jr., and Paul Tobler.

**Figure 60. Assistant-in-Training for
Sugar Factory Technology, 1957-1959:
Menillio Bello.**

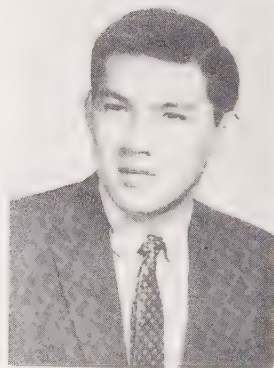




Figure 61. Plantation Trainees for Sugar Factory Technology, 1957:
Kiyoshi Masaki, Yoshito Nagata, Henry G. Voss.



Figure 62. Plantation Trainees for Agriculture, 1957: Tim Lyons, M. Nishimoto, Douglas Pillans, W. Subica, E. Oroc, E. Sasaki, J. Wakatsuki, B. Nishimoto, and C. Guerreiro.

EXPERIMENT STATION STAFF

September 30, 1957

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MOLOKAI QUARANTINE STATION

GEORGE OTSUKA.....	Field Laboratory Superintendent
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CHEN-CHUAN TU.....	Associate Technologist	RAY SPELLMAN.....	Laboratory Assistant
G. F. B. APPEL, JR.....	Assistant Technologist	R. H. OKAMOTO.....	Laboratory Technician

TRAINING OF PERSONNEL

W. P. ALEXANDER.....	Principal Coordinator
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STATION PERSONNEL CHANGES

October 1, 1956 to September 30, 1957

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PAUL IKENE
W. H. KAHL
K. KAWAMURA
F. M. NOMURA
R. H. OKAMOTO
K. M. ONNA
W. W. SEWELL
T. R. UYECHI
R. E. WARNER

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Laboratory Technician
Genetics Assistant
Project Engineer
Laboratory Assistant
Genetics Technician
Laboratory Technician
Assistant Technologist
Project Engineer
Assistant Design Engineer
Assistant Entomologist

PHYSIOLOGY & BIOCHEMISTRY
AGRONOMY
GENETICS
FIELD ENGINEERING
AGRONOMY
GENETICS
SUGAR TECHNOLOGY
SUGAR TECHNOLOGY
FIELD ENGINEERING
FIELD ENGINEERING
ENTOMOLOGY

LEFT THE STAFF

GERALDINE KAU
F. M. NOMURA
G. K. OKAMURA
H. M. SAKAI
R. E. WARNER

Agronomy Assistant
Genetics Technician
Design Draftsman
Substation Technician
Assistant Entomologist

AGRONOMY
GENETICS
FIELD ENGINEERING
OAHU SUBSTATION
ENTOMOLOGY

RETIRED

R. E. DOTY

Associate Agronomist

AGRONOMY

DECEASED

H. L. LYON
J. M. CANARIO

Director Emeritus
Assistant Superintendent

ADMINISTRATION
BUILDINGS & GROUNDS

ON LEAVE OF ABSENCE FOR MILITARY DUTY

E. S. KUROKAWA

Laboratory Technician

ORGANIC CHEMISTRY

